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CAPE TOWN STATE OF ENERGY AND CARBON 2021

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FOREWORD

Since the last State of Energy in 2015, the national energy sector has been through a period of continued turmoil, but thankfully, it has also finally been acknowledged that government alone cannot solve the energy crisis.

The expansion of the scope of this publication to a 'State of Energy and Carbon' reflects the critical role of energy supply in climate action. Our economy needs a clean, reliable electricity supply.

Load-shedding across South Africa continues to limit economic growth, and electricity price increases add an unnecessary burden to households already under financial pressure. Coal-fired electricity remains the largest source of greenhouse gas emissions even as the recent 6th Assessment Report of the International Panel on Climate Change (IPCC) has highlighted the need for immediate multilateral action on climate change. The expansion of the scope of this publication to a 'State of Energy and Carbon' reflects the critical role of energy supply in climate action. Our economy needs a clean, reliable electricity supply. This has placed electricity sector reform front and centre of policy at all levels of government. The best thing the City can do right now to significantly reduce carbon emissions is to reduce reliance on Eskom power and use renewable technology to end load-shedding, over time, in Cape Town.

The overview of our local electricity distribution system in this publication highlights its complexity and the institutional and engineering challenges that lie ahead. Electricity generation, as with many other public service sectors, places our city in a complex national system built up by many decades of public investment drawn from the taxation of generations.

The data presented here show how rapidly electricity consumption patterns have changed and self-generation has grown. This is challenging the revenue model of utilities globally, requiring a new approach to the business.

Rapid urbanisation continues to drive the growth in the number of low-income electricity customers. Free basic electricity and subsidised tariffs remain one of the most direct, transparent and unequivocally beneficial means of social support at our disposal. Cape Town and the other metropolitan cities, many of whom are also members of strong climate advocacy networks, face the difficult challenge of transforming our utility businesses while trying to maintain strong cross-subsidisation of poorer customers, maintain existing infrastructure, transition to a radically different technology paradigm, reduce emissions and improve reliability. This has to be done while collaborating with and supporting the troubled national utility and its national system operator to whom we are bound by long association and the umbilical cord of the 1 400 km long transmission line that injects our economy with the lifeblood of electricity.

The City of Cape Town is making progress with on-the-ground projects. The first carbon credits were awarded to the landfill gas capture and flaring project at Coastal Park this year under the UN-approved Clean Development Mechanism (CDM). A waste-to-energy plant is being installed on the site that will use the gas to generate electricity, further reducing emissions and supplying much needed clean energy. Indeed, the immediate de-carbonisation challenge is in the waste sector where the provincial government is driving extremely challenging short-term organic waste diversion targets that will require all institutions and citizens to get on board. This is also a landfill space challenge. In the same way that we had to learn to use water differently in the drought, we need to treat waste differently and we cannot continue to throw it into a giant hole where it produces emissions. A less wasteful circular economy and new energy technologies, however, offer exciting green economy opportunities, reflected locally in the expansion of enterprises utilising waste streams and embedded generation, and globally by the scaling of electric vehicles, and increasingly, hydrogen production and technologies.

Our greenhouse gas emissions are relatively stable, but demand for petroleum fuels continues to grow strongly. Indeed our transport system has profoundly changed locally and is one of the most direct ways we as a community have experienced a national administration in crisis. A failing rail system, neglected, vandalised and sabotaged on an organised scale has been largely substituted by a resurgent minibus taxi industry, even as the private car population steadily increases. The City, however, remains committed to the long journey begun in the lead up to the 2010 World Cup: to expand a world-class scheduled bus service across the city as it simultaneously directs urban planning towards a more spatially efficient city that can sustain mass transit.

Cape Town has been commended for the quality of its data, having been awarded a number of A-ratings by the global platform, the Carbon Disclosure Project, including in 2021. This year the full data set of the State of Energy and Carbon is available digitally on the City's Open Data Platform for the first time. The recent Data Strategy, the development of a data science competency, and new internal digital tools like SmartFacility that reports the metered electricity, and lately water consumption, of over 800 City facilities covering 93% of consumption, now also support the established data efforts of the line departments. This publication is notable for narrative content contributions from a number of our technical professionals, which reflects a deepening of capacity in key areas. Practical and data-rich, it highlights just some of the areas where the quiet interventions of local government, often unfairly criticised, continue to tackle impossible trade-offs on a daily basis. On a stormy Cape night when the humble heroes of our utilities labour to restore service, spare a thought for their many challenges.

Geordin Hill-Lewis

Executive Mayor,
City of Cape Town

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ABBREVIATIONS

AC	alternating current
ACSA	Airports Company South Africa
B-BBEE	broad-based black economic empowerment
BRT	bus rapid transit
CAIDI	customer average interruption duration index
CBD	central business district
CCAP	Climate Change Action Plan
CDP	Carbon Disclosure Project
CER	certified emissions reductions
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COUE	cost of unserved energy
Covid-19	coronavirus disease
DC	direct current
DFFE	Department of Forestry, Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
EASIA	enable, avoid, shift, improve, adapt
ECC	Energy and Climate Change (Directorate)
EEDSM	energy-efficiency demand-side management
EGD	Electricity Generation and Distribution (Department)
EPR	extended producer responsibility
ERA	Electricity Regulation Act
EV	electric vehicle
FBE	free basic electricity
GBCSA	Green Building Council of South Africa
GHG	greenhouse gas
GW	gigawatt
HVAC	heating, ventilation and air conditioning
HySA	Hydrogen South Africa
ICE	internal combustion engine
IDP	Integrated Development Plan
IMO	International Maritime Organisation
IPP	independent power producer
IRP	Integrated Resource Plan
KPA	key performance area
kWh	kilowatt hour
LED	light-emitting diode

LINES	Low-Income Energy Services (Unit)
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MFMA	Municipal Financial Management Act
MVA	megavolt amperes
MW	megawatt
MWh	megawatt hour
NDC	nationally determined contribution
NERSA	National Energy Regulator of South Africa
NGER	National Greenhouse Gas Emissions Reporting
NGO	non-governmental organisation
NWMS	National Waste Management Strategy
NZC	net-zero carbon
PJ	petajoule
PRASA	Passenger Rail Agency of South Africa
PTNG	Public Transport Network Grant
PV	photovoltaic
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SA LEDS	South Africa Low-Emission Development Strategy
SAGERS	South African Greenhouse Gas Emissions Reporting System
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index
SALGA	South African Local Government Association
SANS	South African National Standard
SDG	sustainable development goal
SEM	Sustainable Energy Markets (Department)
SFA	strategic focus area
SSEG	small-scale embedded generation
SWH	solar water heater
tCO_2e	tonnes of carbon dioxide-equivalent
TOD	transit-oriented development
UDI	Urban Development Index
VOC	vehicle operating company
WISP	Western Cape Industrial Symbiosis Programme
WWTW	wastewater treatment works

INTRODUCTION

This fourth iteration of Cape Town's State of Energy report, previously published in 2003, 2009 and 2015, aims to provide a data-rich evidence base for decision makers, support for researchers and planners, as well as operational transparency in the important energy sector, both in municipal ('City') operations and the wider (city of) Cape Town. This publication also showcases the continued high performance of the City's distribution utility in difficult circumstances, of which customers are often unaware. In addition, the data serves as an essential input for the City's new Climate Change Strategy and Climate Change Action Plan produced this year, which will be even more ambitious than previous versions. Since emissions data constitutes such a key component of this report, its title has been changed to State of Energy and Carbon.

Much has happened in the energy space since the last publication, and the electricity sector in particular has been afflicted by unprecedented turmoil. This has included compounding large real-price increases; spiralling debt at national power utility Eskom; megaproject delays; damaging public allegations of corruption across the value chain; supply interruptions (load-shedding), particularly in 2015, 2019, 2020 and 2021 (the worst year so far); and low average availability of very large thermal plants, which poses the risk of continued interruptions in supply. Embedded generation capacity has increased exponentially in both residential and commercial sectors, partly as a result of the issues above, but also because of fast-dropping costs. A programme of reform and unbundling at Eskom, as well as national regulatory amendments, have, however, promised sector reform to keep pace with the times. Renewable-energy capacity procurement has resumed, bringing much-needed supply, but also dilution of coal power and potential for significant aggregation. The Energy Regulation Act was amended in October 2020 (DMRE, 2020) to allow municipalities to apply to the minister for the right to 'procure or buy' new generation capacity. Further amendments to schedule 2 of the act, gazetted in their final form in August 2021, lifted the licensing exemption threshold to 100 MW, notably for electricity wheeled to one or more customers (DMRE, 2021). These developments open up opportunities for the City to play a role in securing and decarbonising its energy supply.

In the transport energy realm, congestion prior to Covid-19 increased rapidly against the backdrop of a rail system in crisis. The minibus taxi industry saw slow negative growth prior to 2013, but boomed again to fill the gap. Urbanisation has continued apace, driving both formal and informal settlement on the urban periphery, and creating unprecedented challenges for all aspects of service delivery. Large numbers of workers continue to work from home during the Covid pandemic. However, while this has reduced transport energy demand and pollution, it has also damaged local economies and reduced the viability of certain public transport routes. A question mark hangs over the local petrochemical industry after a fire at the Astron oil refinery. Yet new opportunities present themselves as hydrogen technologies begin to scale globally.

In the meantime, climate change ambition has increased in the large metros, with eThekwini, Johannesburg, Tshwane and Cape Town all committing to Paris Agreement-compliant climate action plans through the C40 Deadline 2020 programme, which aims for the near elimination of carbon emissions (carbon neutrality) by 2050. The City has formalised these commitments in a new Climate Change Strategy, which Council approved on 27 May 2021. This will be followed by a Climate Change Action Plan, which will detail the actions needed to set Cape Town on a trajectory of climate resilience and carbon neutrality. National policy has also shifted. The Low-Emission Development Strategy published in 2020 signals the intention to shift national targets in line with the Paris Agreement. Moreover, the nationally determined contributions (NDCs) of 2021 commits the country's GHG emissions to peak between 2020 and 2025 and decline in absolute terms thereafter.

Energy supply and demand are undergoing a profound transition, even as the country is grappling with great social and economic shifts. The role of data for evidence-based decision making has never been greater. Therefore, this edition of the State of Energy and Carbon report is aptly transition themed and aims to articulate the key local energy challenges, including energy poverty, the role of municipal distribution utilities, decarbonisation and transport systems, but also some of the responses that local government and other stakeholders are exploring. An expanded team of energy professionals in the Sustainable Energy Markets (SEM) Department of the Energy and Climate Change (ECC) Directorate of the City have overseen and actively partnered in the internal development of the report's content. SEM's supporting role for the utility department Electricity Generation and Distribution (EGD) has allowed increased access to information and insights from those at the leading edge of service delivery. While the publication is as data-rich as previous editions, much of this detail has been concentrated into statistical annexures for easy reading and reference by different audiences.

As noted in previous editions, the process of developing the State of Energy and Carbon report is an important opportunity to engage stakeholders across the city, and to develop people, professional relationships and an understanding of how energy and emissions play out across service sectors. Therefore, this report builds on firm foundations to support the transition of Cape Town's energy system and the decarbonisation of its economy in the decade to come.

2 THE STATE OF LOCAL ENERGY AND CARBON DATA IN THE DATA AGE

While the City's energy data collection and analysis have indeed become more systematic as envisioned by previous editions of this report, the City is indebted to Sustainable Energy Africa for bringing their unique skills to bear in filling key gaps and collating, validating and organising an enormous body of statistics. Like so many other areas in South Africa, data generation comprises a mix of state-of-the-art and developing-world methodologies. Making sense of the sometimes partial picture was an arduous task carried out by both internal and external teams. This edition of the State of Energy and Carbon report reflects the strides made in data management in the City, which now posts a significant amount of detailed data on its Open Data Platform so that the data can be easily repurposed and distributed.

In general, the data landscape has improved compared to previous years in terms of the scope of sources and the professionalism of personnel involved. However, the following general data problems persist:

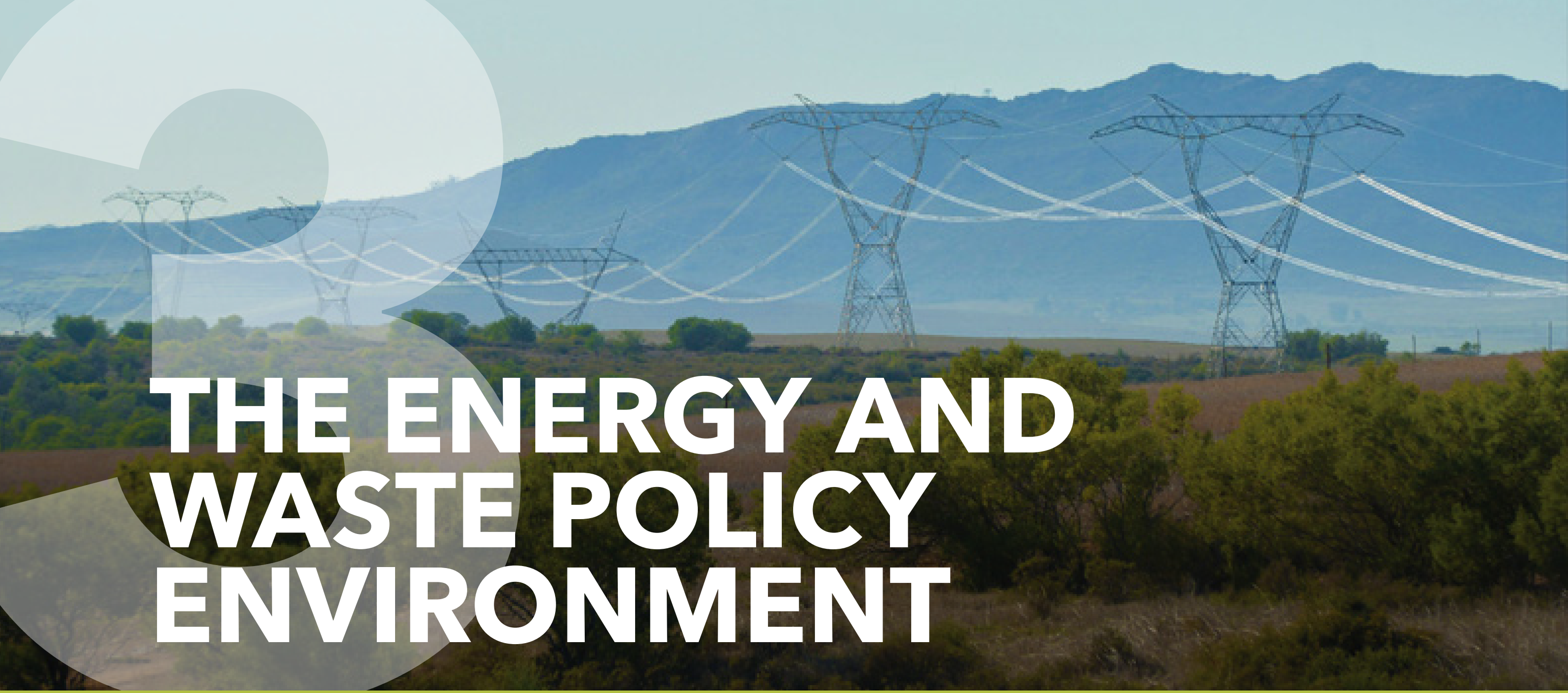
- In most cases, there is a complete lack of scientifically relevant metadata.
- Data are often poorly validated.
- Data are frequently published in non-machine-readable formats, in discreet files and for short time periods, making repurposing very difficult.
- Organisations without a data mandate have a poor culture of transparency and are reluctant to respond to requests for data. The prevailing principle is that all data are proprietary until there is a compelling reason or explicit external instruction to make the data public, instead of the other way around. Yet a competitive economy and, indeed, a healthy society require a strong public data culture. This can be achieved within the parameters of the Protection of Personal Information Act (POPIA) through clear data policies that ensure that private data are anonymised or aggregated.

Unfortunately, the quality of data for petroleum fuels in particular has deteriorated markedly. To date, transport energy demand and emissions have been simply estimated from the fuel sales indicated in the National Department of Mineral Resources and Energy's annual surveys of oil majors, who report their sales by magisterial district. However, metadata for published fuel sales are largely non-existent, and the structure of the industry has significantly changed with the emergence of large independent wholesalers. Industry members have previously cautioned that spatially disaggregated fuel sales data should be interpreted with caution due to the ongoing shifts in how the depots of oil majors and other distribution nodes are supplied from bulk storage (Moldan, 2008). This situation is now aggravated by large-volume purchases from the oil majors by un-surveyed entities, mostly wholesalers, who then redistribute the fuel. A recent study that balanced fuel supply data with vehicle registration data for all the local municipalities in the Western Cape concluded that as much as 10–30 petajoules (PJ) of the 120 PJ (8–25%) demand for petrol and diesel in the province is uncertainly distributed (EScience, SEA and CAPIC, 2019).

The uncertainties for the other petroleum fuels – liquefied petroleum gas (LPG), fuel oil, paraffin and aviation kerosene (jet fuel) – are potentially higher as suggested by recent data fluctuations. This was mitigated for aviation kerosene in this edition because one entity, Airports Company South Africa (ACSA), reports all volumes passing through storage facilities at Cape Town International Airport to the National Energy Regulator of South Africa (NERSA), who was willing to allow sharing of the aggregate data. The other fuels have diverse markets, however, and it is unclear in the case of LPG and fuel oil whether the recent large drops in the supply-side data point to only one or two large consumer firms closing operations, or whether those volumes are being reported in another region.

Future editions of the State of Energy and Carbon report will need to implement the following measures:

- Model-based estimates for road transport petrol and diesel demand
- A data-sharing agreement with the Department of Forestry, Fisheries and the Environment (DFFE) to access local firms' data exceeding the mandated emissions thresholds, as reported to the South African Greenhouse Gas Emissions Reporting System (SAGERS)
- Assisting the City's Air Quality Management Department to update their survey of firm-licensed combustion data on the air quality management database, as reported to DFFE, so as to address any gaps
- Site visits and direct surveys of large industrial energy consumers



3 THE ENERGY AND WASTE POLICY ENVIRONMENT

3.1 NATIONAL POLICY AND LEGISLATIVE CONTEXT

South Africa's energy governance has been centralised under national government for almost a century. The country's energy future, however, is becoming an increasingly significant subject of contestation. This is due to greater awareness of the crisis at the national electricity utility Eskom, coupled with the sustainability issues in the electricity supply system and the associated economic impact on the country. Furthermore, mounting global pressure for electricity and utility reform, disruptions caused by new technologies, and the imperative of climate change response are changing the global energy landscape as we know it.

The South African energy policy and regulatory landscape has also seen a number of changes since the last edition of the State of Energy report in 2015. The most notable is perhaps the updated Integrated Resource Plan (IRP) of 2019, which provides the country with a blueprint for its envisaged energy mix by 2030. According to the 'policy-adjusted' plan, coal generation remains a significant component of the generation mix, supplying approximately 60% of the country's electricity needs by 2030. The plan does show a shift towards renewables, however, with wind and solar meeting a quarter of national energy needs by 2030. Other clean technologies in the plan include hydropower and battery storage, which will collectively meet approximately 10% of electricity needs by 2030. The plan has been praised for its proposed increased allocation to renewable-energy, the phasing out of coal and the deferral of new nuclear capacity to beyond 2030. Yet it lacks clarity on embedded generation and the critical role of larger metros in electricity supply and demand.

There have also been a number of significant amendments to the Electricity Regulation Act (ERA) of 2006, including the following:

- On 10 November 2017, generation facilities up to 1 MW in capacity with sole buyers and co-generation facilities of unspecified capacity, but for the sole use of the owner, were exempted from licensing processes, but are still required to register with the regulator.
- On 16 October 2020, following years of dialogue and even legal exchanges between the stakeholders, the ERA was amended to allow municipalities to apply to the minister to 'procure' or 'buy' new generation capacity in accordance with the Integrated Resource Plan (IRP).

There have been wide industry calls for the licensing exemption to be increased to 50 MW to alleviate supply shortages. A new national procurement programme, the Risk Mitigation Independent Power Producer Procurement Programme, has completed its bidding process and promises to relieve constraint. However, the process and its outcome resemble a heavily disguised resort to oil and gas price-indexed, fossil-fuelled, rented power capacity, no different from that seen in Kenya, Ghana and elsewhere where similar supply crises were experienced.

Other legislation and policies crucial to the sector that have recently taken effect include the National Greenhouse Gas Emissions Reporting Regulations (NGER) (2017, amended in 2020) under the National Environmental Management: Air Quality Act of 2004, the Carbon Tax Act (adopted in June 2019) and the new national Low-Emission Development Strategy 2050 (adopted in 2020). The NGER is aimed at developing a standardised method to report GHG emissions that could aid the updating of the national GHG inventory and inform the formulation and implementation of legislation and policy. The regulations should be read alongside the draft Technical Guidelines for Validation and Verification of Greenhouse Gas Emissions. These guidelines aim to ensure that the submitted GHG emissions reports are complete and transparent, and address the previous data accuracy challenges. GHG emissions reports will be used to determine which entities are liable to pay carbon tax. Therefore, the reports form the backbone of the Carbon Tax Act, which gives effect to the polluter-pays principle for large emitters and aims to ensure that firms and consumers take the adverse costs (externalities) into account in their future production, consumption and investment decisions (National Treasury, 2019). Although a major regulatory step forward in South Africa's attempt to curb carbon emissions, the Carbon Tax Act has been criticised for its relatively low carbon price. (See section 3.2 for more on the Carbon Tax Act.) The gathering and reporting of GHG data are a crucial component of a required broader climate change regulatory mechanism, which is to be provided under a much-needed, robust Climate Change Act (CER, 2019). According to the DFFE, the Climate Change Bill is being finalised and has been earmarked for completion in 2021. The IRP (2019), NGER, Carbon Tax Act and Climate Change Bill are the key legislative and policy instruments that support South Africa's Low-Emission Development Strategy (SA LEDS). SA LEDS has been developed in response to the Paris Agreement's call for long-term climate strategies, and outlines the efforts required to become carbon neutral by 2050.

Energy and carbon policy advances in the transport sector include the Green Transport Strategy (2018–2050), which is South Africa's first strategic document that sets out the policy direction for transport. The strategy aims to promote green mobility so that the transport sector can support the achievement of green economic growth targets and help protect the environment. It envisages a decarbonisation narrative for the sector by encouraging the shift to electric vehicles and improving public transport.

New and amended national and provincial legislation and regulations are set to drive major changes in the handling of a number of key waste streams, notably organics. The Provincial Department of Environmental Affairs and Development Planning's plan requires a 100% ban on organic waste sent to landfill by 2027. This will require municipalities to set annual targets, and to identify and implement procedures to meet such targets (GreenCape, 2019b). The National Waste Management Strategy (NWMS) published in 2020 has set targets to reduce waste disposal to landfills by 40% in the next five years, 55% in the next 10 years, and 70% in the next 15 years. The long-term goal is to have zero waste going to landfill. Local government has been listed as a key player in the implementation of the NWMS, given its waste collection and disposal services and infrastructure mandate (DEFF, 2020). However, diversion at source across thousands of customers is complex, requiring extensive behaviour change, and could be expensive, with implicit tariff increases in the absence of national financial assistance in an adverse economic climate. Therefore, it is not clear how these targets will be achieved.

In summary, some progress has been made in electricity regulatory reform since the previous publication in this series. While as yet untested, the City has welcomed the ERA amendments, as they acknowledge that municipalities have a role to play in new generation development. For the time being, however, generation expansion is still centrally planned, and can only be procured under ministerial determination, while Eskom remains vertically integrated, the sole buyer of significant quantities of electricity, and the system operator. Therefore, it remains uncertain how much control metropolitan governments will have over their ambitious cleaner-energy targets to meet city-level carbon-neutral 2050 goals. Transport has seen a moderate response to the need to decarbonise. In the waste sector, there has been a major regulatory response, though it has resulted in a disconnect with local government's ability to meet targets. In an era of voluntary corporate reporting on platforms such as the global Carbon Disclosure Project (CDP), and increasing citizen pressure to decarbonise in large markets, we could see a future trend of decarbonisation not driven by policy or regulations, but via market forces. Consequently, getting caught up in the constraints of a legally driven approach poses a growing risk to Cape Town of falling behind and having a highly carbon-intensive economy in a world that is transitioning away from carbon.

See statistical annexure 10.2 for an overview of relevant national energy, carbon and waste legislation, strategy and plans.

3.2 CARBON TAX AND CARBON OFFSETTING

Due to South Africa's heavy reliance on fossil fuels, particularly coal, it is ranked as the 14th largest global CO_2 emitter (WEF, 2019). South Africa ratified the Paris Agreement in 2016, and the country's Carbon Tax Act took effect in June 2019, following nine years of extensive consultation and debate.

The overall objective of the Carbon Tax Act is to reduce GHG emissions by incentivising renewable-energy and low-emission processes. The act is underpinned by the polluter-pays principle, which ensures that any persons or entities exceeding a threshold will be liable to pay a carbon tax – currently set at R120 per tonne of carbon-dioxide-equivalent emissions (tCO_2e) (National Treasury, 2019). However, the tax design provides for a series of tax allowances to be introduced in the first phase (1 June 2019 – 31 December 2022), which will reduce the initial effective tax rate.

With all tax allowances considered, businesses can reduce their carbon tax liability by up to 95%, which translates into a far lower value of R6–R45/tCO_2e (National Treasury, 2019). The initial tax rate of R120/tCO_2e (US$8/$tCO_2e$) has been criticised for being relatively low. It has been estimated that an explicit carbon-price level consistent with achieving the Paris temperature target is at least US$40–US$80/tCO_2e by 2020, and US$50–US$100/tCO_2e by 2030 (Carbon Pricing Leadership Coalition, 2017). Yet initial tax rates can be significantly lower as a means to facilitate transition, especially in carbon-intensive economies. Stronger policies/instruments or higher carbon prices would be required to follow later, so that the objectives of the Paris Agreement are met.

The Taxation Law Amendment Act, 34 of 2019, has amended the definition of 'person' in section 1 of the Carbon Tax Act to the extent that municipalities are now regarded liable to pay carbon tax. The City may consider offsetting its tax liability through the sale of certified emissions reductions (CERs), which has become feasible through the Carbon Offsetting Regulations published in November 2019.

3.3 ENERGY AND WASTE-RELATED LOCAL GOVERNMENT MANDATES AND FUNCTIONS EMANATING FROM NATIONAL POLICY

The objects of local government according to the Constitution of the Republic of South Africa (1996) include the provision of services to communities in a sustainable manner, and the promotion of social and economic development, as well as a safe and healthy environment (section 152(1)). The Constitution also sets out the powers and functions of municipalities (section 56(1) and schedules 4B and 5B), which include some aspects relating to air pollution, building regulation, electricity and gas reticulation, municipal planning, waste collection, disposal services and associated infrastructure. These functions have strong energy and waste-related implications. Therefore, as municipalities derive authority from the Constitution to intervene in these matters, they are empowered to develop policy and legislate on energy efficiency, renewable energy, as well as waste management within their jurisdictions (City of Cape Town, 2015).

Section 23 of the Municipal Systems Act, 32 of 2000, requires municipalities to produce integrated development plans (IDPs) for the medium-term development of their municipal areas to meet their communities' needs. The section provides that the orientation of these plans must be developmental and sustainable. The Municipal Systems Act directs municipalities to provide sustainable services to their communities, and promotes increased community involvement in the provision of energy services. Furthermore, the IDPs must include integrated waste management plans to ensure the proper planning and management of waste. Section 156(5) of the Systems Act also states municipalities' right to "exercise any power concerning a matter reasonably necessary for, or incidental to, the effective performance of its functions".

Municipalities are identified as key partners, and the South African Local Government Association (SALGA) as a key support, in the implementation of lower-carbon pathways in the National Climate Change Response Strategy (section 10.2.6), as well as the draft National Climate Change Bill. Should the bill be adopted in its current form, sections 9(1)(a) and (b) will require local governments to prepare climate change needs and response assessments and associated climate action plans.

However, the national legislative environment also poses numerous challenges for municipalities attempting to implement these initiatives. For example, some policies might set targets for the implementation of energy efficiency and renewable energy at national level, without clearly identifying the municipal mandate and associated financial resources. A more recent example of this is the uncertainty as to municipalities' role in executing the updated IRP 2019, considering their electricity distribution role and impact on revenue. If municipalities are expected to contribute, as is broadly indicated in national policies, these responsibilities need to be translated into specific key performance areas (KPAs) in municipal management systems. The Municipal Finance Management Act, 56 of 2003, in turn, regulates municipal procurement procedures and has proved challenging in relation to the demands of both energy-efficiency and renewable-energy project implementation, which often requires long-term contracting. This is unpacked further in the section below in the context of municipalities' role as electricity distributors.

3.3.1 LEGISLATION AND POLICY GOVERNING ELECTRICITY DISTRIBUTORS

BACKGROUND

In the evolution of electricity supply and governance in South Africa, municipalities have generally played a fairly small part. Governance of energy matters has been centralised with national government, and municipalities' role has been limited to that of electricity distributors and owners of local electricity reticulation systems. However, the Constitution affords municipalities independent status as autonomous organs of state. It also imposes obligations on municipalities to secure the health and well-being of local citizens as described above. Yet section 34 of the ERA entitles the energy minister to control the identity of the purchaser when (s)he makes a determination that new generation capacity is needed to ensure continued uninterrupted electricity supply (Mosdell, 2016).

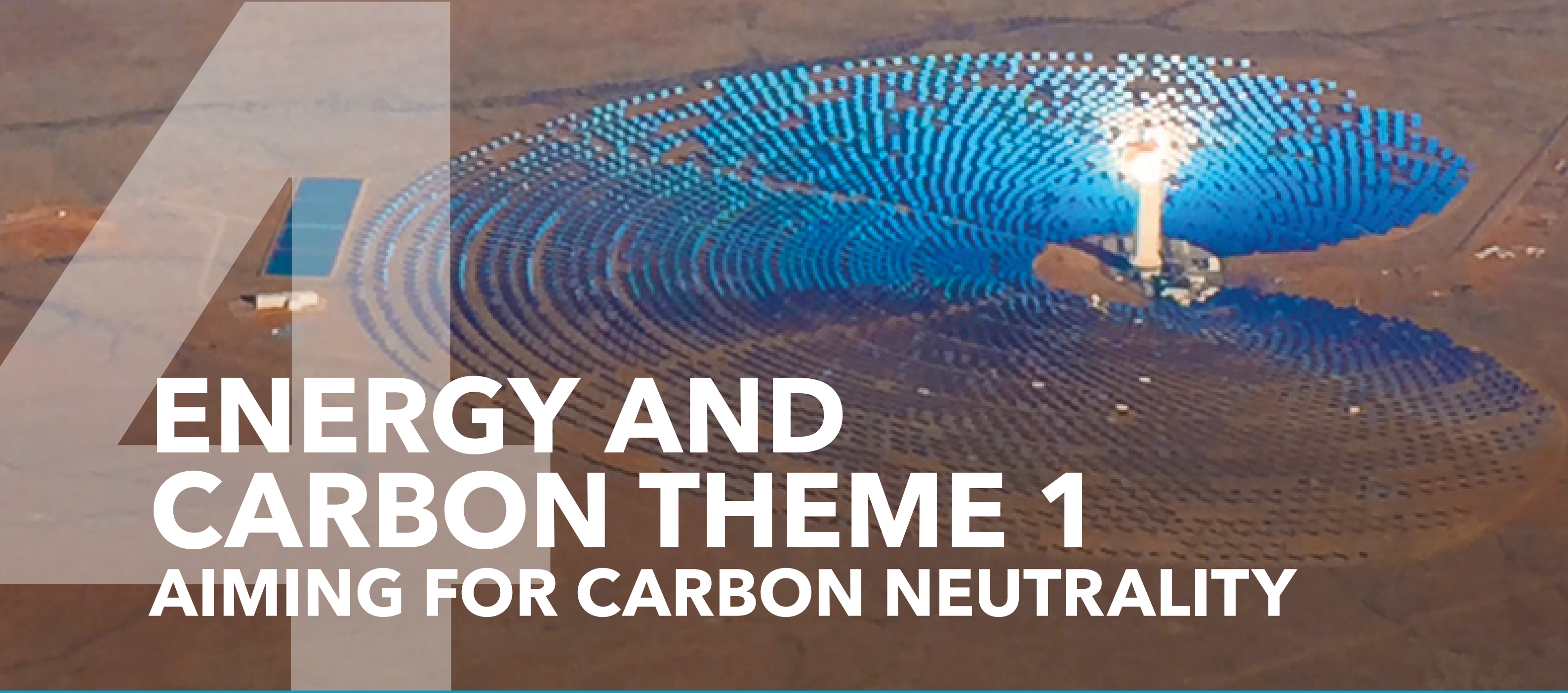
Government has been using this provision to retain Eskom's role as the sole entity managing grid-connected electricity. Section 34 is also the provision in terms of which the minister established the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). Currently, only Eskom is authorised to purchase electricity from this programme. A municipality wishing to ensure security of supply for its citizens by purchasing electricity directly from an independent power producer has to seek a determination from the minister, designating it as the purchaser of electricity from a source chosen by the minister in terms of section 34, or from a source procured by the municipality (Mosdell, 2016).

PROCUREMENT

Municipalities are subject to general national procurement legislation, such as the Preferential Procurement Policy Framework Act, as well as to specific municipal procurement legislation, being the Municipal Finance Management Act and its supply chain management regulations. Therefore, procurement legislation adds layers of complexity to the already highly regulated electricity environment, and creates many challenges. Table 1 below details the most immediate requirements that the City needs to adhere to in procuring electricity.

TABLE 1: SUMMARY OF THE MOST PERTINENT REGULATIONS AND POLICY INSTRUMENTS AFFECTING LOCAL GOVERNMENT ELECTRICITY PROCUREMENT

Name	Type	Description
National Energy Regulator of South Africa (NERSA)	Licensing requirement	All generators, distributors and traders of electricity in South Africa require a NERSA-issued licence. The licensing requirement is created by the ERA, read together with the NERSA Act, thereby making it a legislative requirement as well.
Electricity Regulation Act (ERA)	Act	Gives the energy minister sole discretion to determine procurement in terms of quantity and type of generation.
Integrated Resource Plan (IRP)	National policy document	Stipulates technology choice limitations that need to be adhered to.
Preferential Procurement Policy Framework Act (PPPFA)	Act	Stipulates minimum procurement requirements with regard to black economic empowerment and local content.
Municipal Finance Management Act (MFMA)	Act	Governs how municipalities procure goods and services.



ENERGY AND CARBON THEME 1

AIMING FOR CARBON NEUTRALITY

4.1 CONTEXT AND CHALLENGES – SOUTH AFRICA'S CLIMATE CHANGE COMMITMENTS

In 2016, South Africa ratified the Paris Agreement. The Paris Agreement is a global climate change deal that serves as a legal instrument to guide the process for universal climate action and obligates all signatory countries to develop and submit their NDCs. The NDCs outline each country's effort to reduce national emissions, adapt to the impacts of climate change, and ultimately achieve the long-term goal of preventing a global temperature rise above 2 °C (pre-industrial levels), preferably limiting the increase to 1,5 °C. This goal requires signatories to reach carbon neutrality (no net GHG emissions) by 2050, while developed economies need to achieve sharply declining trajectories almost immediately. South African president Cyril Ramaphosa has confirmed the intention to enhance the country's NDC[1] and, in December 2020, established a Presidential Climate Change Coordinating Commission to oversee and coordinate the national climate change response. South Africa's second NDC was in the public participation phase at the time of writing.

4.2 CONTEXT AND CHALLENGES – THE LOCAL EMISSIONS AND ENERGY PICTURE IN THE CONTEXT OF TRADE RISK

The energy-related emissions from coal-fired electricity and combustion of petroleum fuels account for 90% of total GHG emissions in Cape Town, as shown in figures 1 and 2. While electricity accounts for the most emissions because national grid electricity is highly carbon-intensive, the city depends on fossil fuels for transport, and emissions from these demands are increasing. Prior to the Covid pandemic, this increase was particularly sharp for aviation kerosene – a key input into the important local tourist industry.

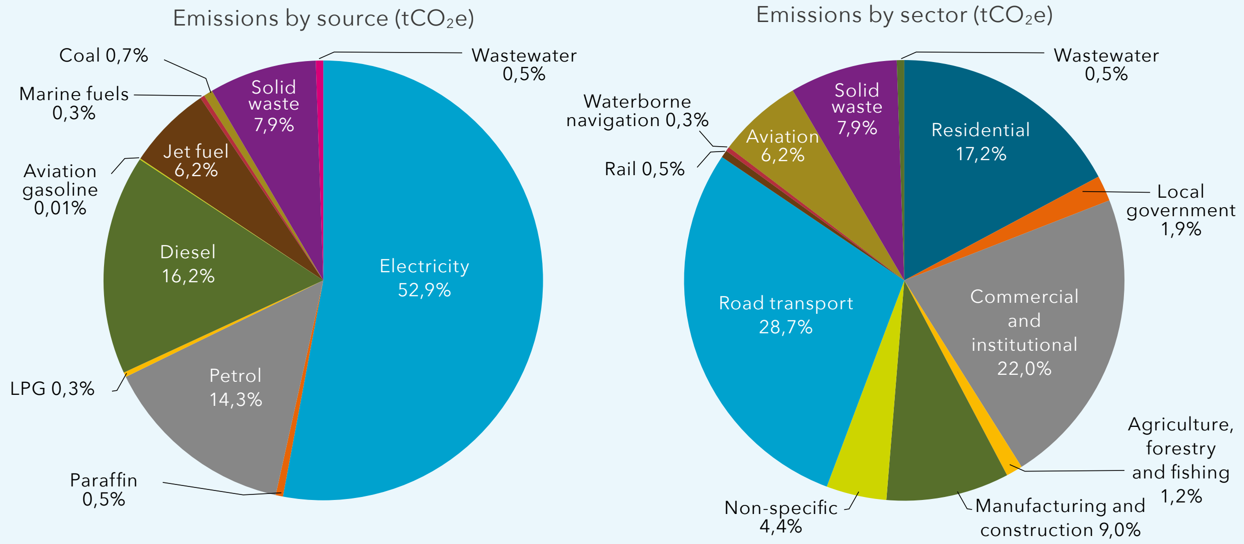
Carbon neutrality by 2050, therefore, implies a wholesale transformation in the way energy is supplied to Cape Town's economy – a transition that is well under way in developed countries. Currently, in addition to intermittent supply constraints, every product and service produced locally carries a burden of embedded carbon arising from our energy-intensive economy and carbon-intensive energy. The global decarbonisation initiative is discernibly shifting from activists and national governments to include subnational governments, consumers and, most importantly, multinational corporations. Carbon-intensive jurisdictions around the world now face not just trade risks from the 'border adjustment' carbon taxes being touted in new green deals in the European Union, but also directly from any global value chains in which they participate.

With the Western Cape, for instance, supplying 55% of the country's agricultural exports, and the local food and beverage sector having been one of few industries to create significant manufacturing jobs in the past decade, the regional stakes in the success of proactive decarbonisation are extremely high. The immediate priority is the electricity sector, where renewable technologies at different scales can be deployed on-site,

1 http://www.dirco.gov.za/docs/speeches/2019/cram0923.htm

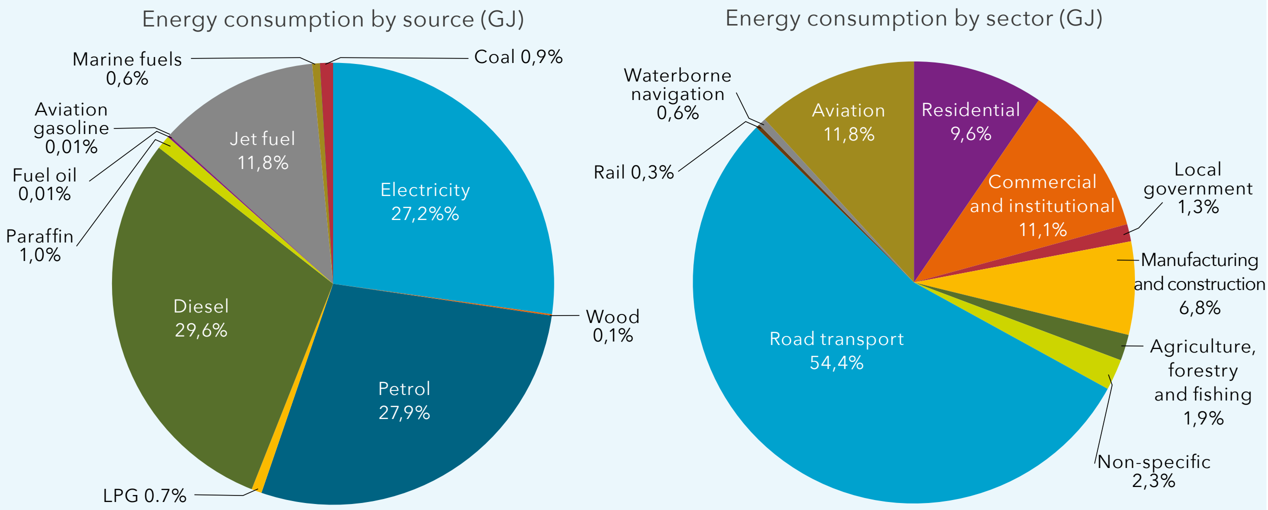
or electricity wheeled across the grid and aggregated to offer a range of immediate options to industry, decarbonising all customers over time. Carbon-neutral molecular fuels are a next step, with hydrogen-based technology starting to scale globally now, and biofuels serving as a possible bridge. Certain industries, such as international flight carriers and film, would need to be prioritised strategically, and government has a clear role in giving unambiguous policy signals, ensuring conducive regulatory design, and partnering in market development, promotion and energy retail systems.

FIGURE 1: 2018 GHG EMISSIONS FOR CAPE TOWN BY SOURCE AND SECTOR SHARES



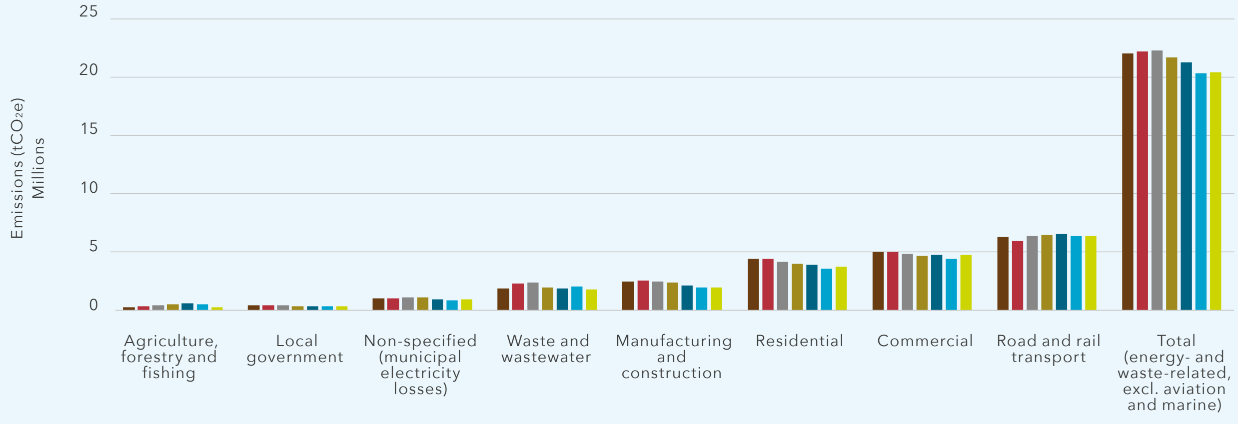
Total GHG emissions (excluding oil refining, for consistency): 21,77 million tCO_2e
Estimated oil refining GHG emissions: 0,68 million tCO_2e. Electricity and non-specified categories include electricity losses.

FIGURE 2: 2018 ENERGY CONSUMPTION FOR CAPE TOWN BY SOURCE AND SECTOR SHARES



Total energy consumed (excluding oil refining, for consistency): 159,7 PJ
Estimated oil refining energy consumed: 9,5 PJ (assumed mostly refinery gas and fuel oil additional to sales). Electricity and non-specified categories include electricity losses.

FIGURE 3: HISTORICAL SECTORAL GREENHOUSE GAS EMISSIONS FOR CAPE TOWN (2012–2018)



4.3 RESPONSES – PARIS-COMPLIANT CLIMATE CHANGE COMMITMENTS

The City acknowledges that delay or failure to take the necessary action to adapt to the impacts of climate change and contribute to global climate change mitigation efforts will lead to greater long-term consequences, as well as missed opportunities in a global green economy. Therefore, in 2018, the City, along with the other major South African metros of Tshwane, Johannesburg and eThekwini, joined over 100 cities worldwide in committing to the C40 Deadline 2020 programme.[2] This programme, coordinated by global advocacy organisation C40 Cities, aims to fast-track climate change response action by member cities, and includes a commitment to develop a climate action plan that is consistent with the requirements of the Paris Agreement. The Paris Agreement requires the world's economies to achieve carbon neutrality by 2050, while adapting to the local impacts of inevitable climate change.

The City's Energy2040 Goal, adopted in October 2015, committed the administration to significantly diversifying Cape Town's energy supply to reduce carbon emissions by 37% by 2040 (off a business-as-usual trajectory), which effectively translated into stabilising annual emissions over the period. Under Deadline 2020, Cape Town is categorised as an 'early-peak' developing city, which needs to peak its emissions by 2030 with a modest rise, and then, by leveraging technology scaled in developed markets, decarbonise rapidly to a minimum of 80% lower than current emissions by 2050. In the longer term, therefore, the new commitments represent a considerable ramp-up in mitigation ambition.

The City's partnership approach to addressing its climate change responsibilities means that it has made commitments at a global level, which involve certain outcomes and timeframes. These include not just citywide emissions, but also sectoral commitments in the building and transport sectors, where cities typically have strong mandates. The current commitments made through the City's C40 membership are outlined in the box below.

The C40 Deadline 2020 programme acknowledges that cities are key role players in reaching the goals of the Paris Agreement and supporting national NDCs. This is based on the understanding that cities can use climate change action to drive a transformative urban agenda, resulting in a reduction of GHG emissions, while preparing for the effects of climate change.

Cape Town's climate change commitments

1. Deadline 2020 programme
   i. Improve Cape Town's current climate resilience, and that of future climate impact scenarios, addressing social needs inclusively.
   ii. Mitigate within at least 20% of citywide carbon neutrality compared to base year by 2050. Interim targets are required that will ensure that emissions peak before 2030 at a level not higher than 30% greater than base-year emissions.

2. Net-zero carbon buildings commitment (citywide and City-owned) – New buildings citywide to be net-zero carbon by 2030, existing and new City buildings to be net-zero carbon by 2030, and all buildings to be net-zero carbon by 2050.

3. Green and Healthy Streets Declaration (formerly the Fossil Fuel-Free Streets Declaration) – Procure, along with our partners, only zero-emission buses from 2025, and ensure that a major area of Cape Town is designated zero emissions by 2030.

2 https://www.c40.org/other/deadline_2020

4.4 RESPONSES – CAPE TOWN'S CLIMATE CHANGE STRATEGY 2021

The City has a long history of responding to climate change through policy, planning, institutional enhancements, as well as programme and project implementation. The City's first fully integrated Climate Change Policy, adopted in 2017, was the product of almost 20 years' work in adaptation and mitigation. An important milestone, the adoption of the Climate Change Policy marked the point at which it was finally recognised that climate change posed a significant threat to Cape Town and required a dedicated policy and strategy approach.

In 2019, a review of the Climate Change Policy determined that the policy should be upgraded to a strategy to ensure that climate change is addressed and integrated at the highest level within the organisation.

The new Climate Change Strategy, which Council approved in May 2021, together with its implementation plan (the Climate Change Action Plan), aligns with the new global commitments that require a more ambitious programme of action.

The Climate Change Strategy organises the work that needs to be done into a framework of strategic focus areas (SFAs), which cover the sectoral and practice areas of adaptation and mitigation, as well as cross-cutting work areas, which enable City and citywide outcomes.

FIGURE 4: TIMELINE OF THE CITY OF CAPE TOWN'S CLIMATE CHANGE STRATEGY, POLICY AND PLANNING PROCESSES

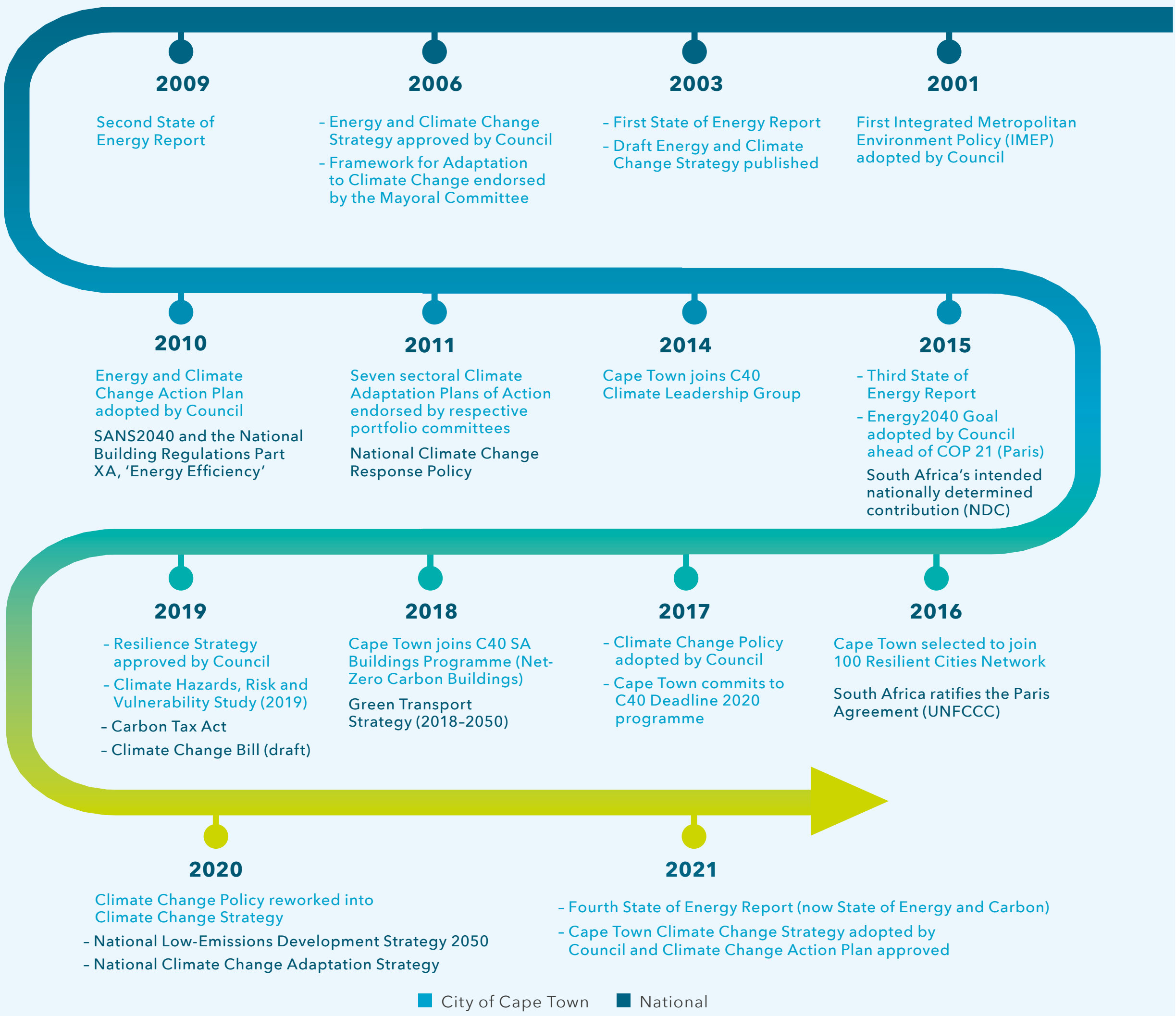
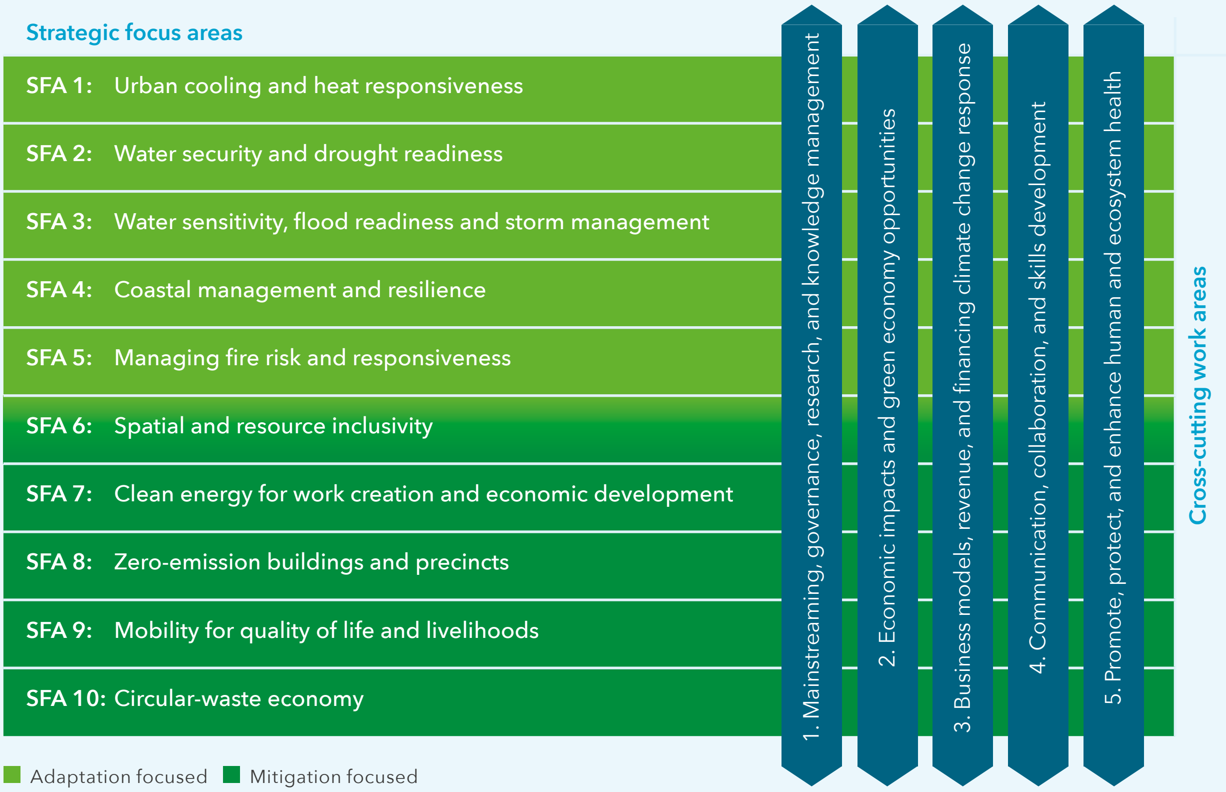


FIGURE 5: CLIMATE CHANGE STRATEGY WORK AREAS



4.5 RESPONSES – ACTION PLANNING FOR CARBON NEUTRALITY AND RESILIENCE BY 2050

The approach in compiling the City's Climate Change Action Plan (CCAP) was to consider detailed GHG inventory and modelling projections along with the Climate Change Strategy goals to identify the key mitigation and adaptation action areas in the local context. Actions that were affordsable, pragmatic and constituted a practical role for the City were developed, refined into programmes and projects, and allocated to lead departments through formal and informal internal engagements.

For mitigation, these cover a transition to renewable electricity, the electrification of the transport fleet, supported by public transport, spatial planning and catalytic urban investments, and the diversion of organic waste at source. The plan is citywide and requires broad-based buy-in. Therefore, communication that engages citizens, business and government as implementers is key, and a communications campaign is being developed to support the roll-out of the plan (see section 8.1.2.2). The CCAP contains 101 actions, organised into the work areas shown above in figure 5. As illustrated below, the actions are of different types and in different phases of development.

In summary, the approach of the CCAP can be summarised as follows:

- The CCAP is more ambitious than previous plans and integrates adaptation and mitigation in a balanced way.
- Extensive engagement was undertaken internally and externally, which will continue on a programmatic basis.
- Although the entire plan is important, it is more urgent to move sooner on certain aspects, such as organic waste diversion, the carbon footprint of City-owned buildings, assessing the climate resilience of City infrastructure, and dealing with informality. The spatial and mass-transit transformation of Cape Town needs consistent commitment over decades.
- In the wake of the Covid pandemic, the plan is fiscally conservative, but has ambitious ultimate goals. It is not a wish list of unproven new technologies. Feasibility studies are required in key adaptation areas. In mitigation, the approach is to adopt technologies as they scale and become economically viable, and prepare for imminent technology such as electric vehicles and hydrogen. A green economy approach through partnerships and procurement practice is emphasised.
- A number of existing large programmes are included, for instance MyCiTi system expansion and water supply augmentation. The plan consolidates the many climate response-relevant actions in the City in one document, fills gaps, and sets a pathway with a suite of new actions to achieve strategic goals.

The strategic focus area, "clean energy for work creation and economic development" lays out the following ambitious aspirational vision for the local energy sector shown in figure 7.

FIGURE 6: OVERVIEW OF ACTIONS IN THE CAPE TOWN CLIMATE CHANGE ACTION PLAN

Action status:	No.
New (concept)	19
New (in planning)	23
Expansion of existing programme	27
Implementation	32
Total	**101**

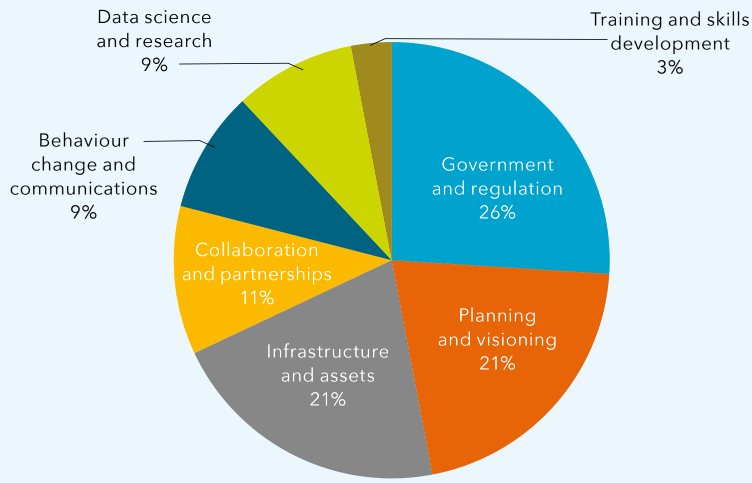
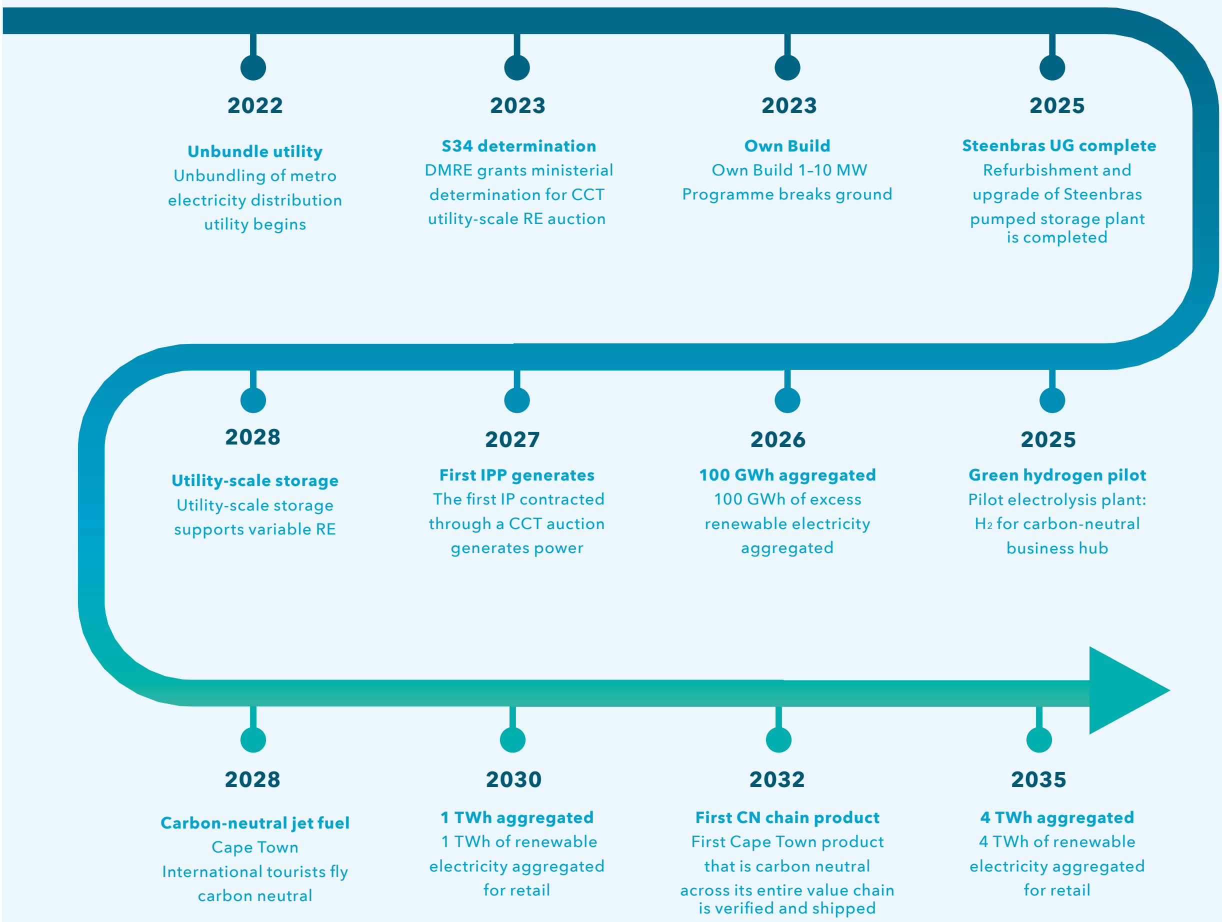


FIGURE 7: A VISION TIMELINE FOR A LOCAL ENERGY TRANSITION THAT WILL REQUIRE THE CITY OF CAPE TOWN TO FULFIL BOTH IMPLEMENTING AND SUPPORT ROLES



4.6 RESPONSES – NET-ZERO CARBON (NZC) BUILDINGS PROGRAMME

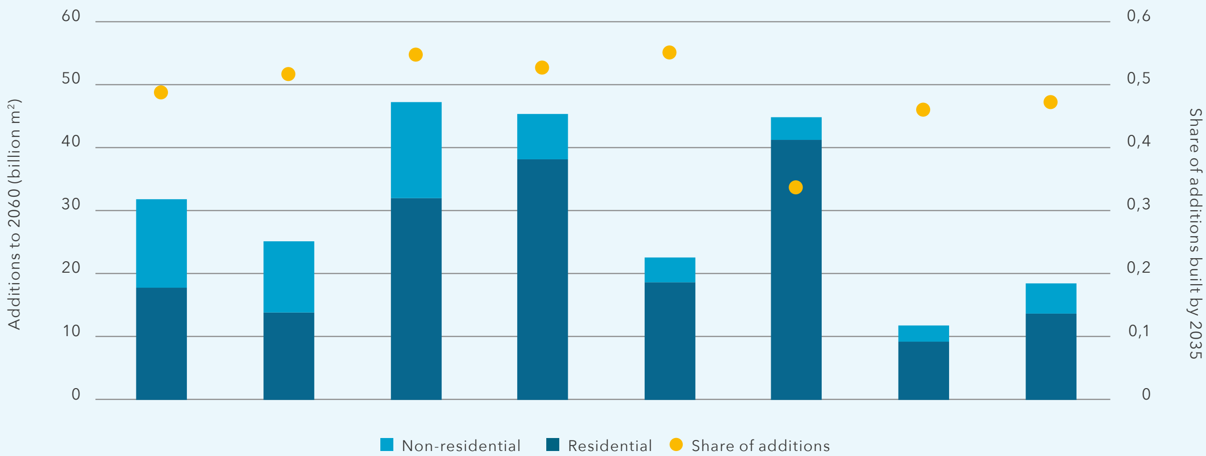
4.6.1 STATE OF BUILDINGS IN CAPE TOWN

Globally, the building stock in cities is growing rapidly. In 2016, the total floor area of buildings globally stood at approximately 235 billion square metres, and it is projected that an additional 230 billion square metres will be added by 2060.[3] Approximately 40% of these additions will occur in developing African countries, as shown in figure 8 below.

Reflecting these anticipated trends, Cape Town's floor area is expected to continue growing rapidly, as indicated in figure 9.

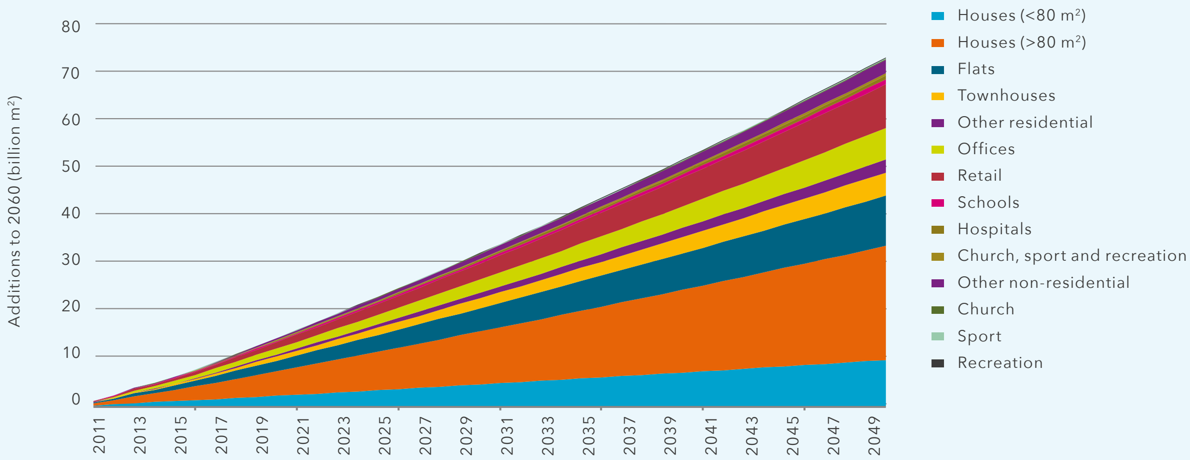
In a business-as-usual scenario, the growth of the building stock will significantly increase Cape Town's GHG emissions, as residential and commercial buildings almost exclusively depend on electricity from the national grid, which, in South Africa, is coal-based and very high in carbon. In addition, buildings have a long lifespan of 40 to 120 years, and any inefficient building built now 'locks in' high energy use into the future. More resource-efficient building approaches will prevent the lock-in of long-term inefficient building investments.

FIGURE 8: FLOOR AREA ADDITIONS BY REGION UP UNTIL 2060



Source: IEA, 2017.

FIGURE 9: FLOOR AREA ADDITIONS IN CAPE TOWN



Source: Sustainable Energy Africa, 2019.

4.6.2 IMPACT OF BUILDINGS ON RESOURCE USE AND CARBON EMISSIONS

The built environment (or 'urban form') produces a third of the world's carbon dioxide (CO_2) and, therefore, needs to be at the forefront of efforts to drastically reduce the amount of CO_2 generated.[4] According to the City's GHG inventory of 2018, residential and commercial buildings in Cape Town account for approximately 21% of energy consumption (refer to figures 1 and 2) and are responsible for the largest proportion of carbon emissions (approximately 39%) due to the high carbon intensity of South African electricity. Of this, the residential sector alone accounts for 10% of total energy consumed, and 17% of citywide carbon emissions (total energy and emissions including marine and aviation).

4.6.3 LEGAL AND REGULATORY FRAMEWORK

NATIONAL LEGISLATION AND POLICY

Section 24 of the Constitution states that everyone has the right to have the environment protected, for the benefit of present and future generations. This is to occur through reasonable legislative measures that prevent pollution and ecological degradation, promote conservation, and secure ecologically sustainable development and use of natural resources, while promoting justifiable economic and social development.

The National Building Regulations, and specifically SANS 10400-XA (2011), regulates the energy efficiency of buildings in South Africa. It provides for mandatory energy-efficiency interventions for all new buildings, as well as for appropriate extensions and renovations. These interventions include optimal orientation, heat loss–gain and thermal resistance, fenestration and double glazing, shading, insulation of floors, ceilings and walls, natural lighting, ventilation and water heating. The regulations have been in place since 2013 and are currently being updated with new energy-use intensity requirements. The recently published updated SANS 10400-XA version 2 (2020) draft regulations introduce more stringent energy-efficiency requirements. Despite the proposed stringent requirements, however, further action is needed to achieve NZC buildings by 2030 in line with the City's climate change commitments. In addition, the National Development Plan identifies the transition to a low-carbon economy and sustainable resource management as one of 10 priority areas, with the imperative to develop regulations towards NZC buildings by 2030.

A summary of other relevant national legislation specific to the built sector is provided in annexure 10.2.

CITY OF CAPE TOWN POLICIES, STRATEGIES, PLANS AND BY-LAWS

The City recognises buildings as a priority action area in mitigating climate change impacts in line with the Paris Agreement's vision of a decarbonised world and the sustainable development goals' vision of equitable climate action.

Priority 4 of the City's IDP (2017–2022) specifies that the City aims to promote resource efficiency and to diversify resource consumption and sourcing. Resource-efficient buildings are aligned with the energy-efficiency project under the energy efficiency and supply programme, as well as the mitigation climate change project under the climate change programme.

CITY OF CAPE TOWN CLIMATE CHANGE COMMITMENTS

As stated earlier, in 2018, the City, together with the metros of Johannesburg, eThekwini and Tshwane, committed to the C40 Deadline 2020 Climate Action Planning in Africa and the C40 South Africa Buildings programmes. These programmes commit participating cities to accelerating transformative climate action by delivering carbon neutrality for all new buildings (and all municipal buildings) by 2030, and citywide carbon neutrality by 2050. These commitments are an extension of the City's Energy2040 Goal (2015) and align with the City's Climate Change Policy (2017), IDP (2017–2022) and the vision and objectives of the City's Energy and Climate Change Directorate.

In addition, at the Global Climate Action Summit in September 2018, the City's Executive Mayor signed the NZC Buildings Declaration, which commits the city to pursuing the retrofit of existing buildings to be NZC by 2050. In its own operations, the City commits to ensuring that all new facilities owned, occupied and developed by the municipality are NZC by 2030, and that the same is true for existing facilities as far as possible. These commitments are in line with national policy directions, supports the intentions articulated in the draft national energy-efficiency and climate change strategies and the National Development Plan, which envisages net-zero emission building standards by 2030.

To meet these commitments, the City is looking to exert greater influence on GHG emissions associated with the operation of buildings through its new building plan approval process, building inspectorate and regulatory functions. To this end, the City seeks to introduce legislative measures that establish the minimum

3 https://gettingtozeroforum.org/un-and-iea-deliver-wake-up-call-to-the-building-sector/
4 https://www.c40.org/researches/mckinsey-center-for-business-and-environment

energy-efficiency requirements of new buildings, and ultimately require renewable energy to meet buildings' demands in pursuit of a NZC building sector. This could be achieved through integrated passive design, higher-performance building envelopes, energy-efficient lighting, as well as heating, ventilation and air conditioning (HVAC), building management systems and appliance specifications. The remaining energy demand would be increasingly met from a renewable source of energy, either on-site embedded generation, City-provided green energy, or the procurement of alternative renewable energy.

Beyond having more stringent energy-efficiency regulatory mechanisms, a multipronged approach to meeting NZC requirements includes:

- increasing awareness and capacity for low-carbon developments;
- campaigns and legal instruments to promote resource efficiency and rooftop photovoltaic (PV) installations in homes;
- considering possible incentive packages;
- mechanisms to support access to finance (for the residential sector in particular) for the upfront capital costs of energy-efficiency and renewable-energy interventions; and
- decarbonising the Cape Town electricity grid by developing City-owned renewable-energy projects and enabling the purchase of large-scale renewable energy from IPPs.

ALIGNMENT WITH THE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Viewing buildings as a priority action area in mitigating the impacts of climate change is in keeping with the vision of equitable climate action advocated by the sustainable development goals (SDGs). Low-carbon buildings can improve people's health and well-being (SDG3), use renewable energy (SDG7), and foster innovation while contributing to climate-resilient infrastructure (SDG9). Low-carbon buildings are the fabric of sustainable communities and cities (SDG11), promote circular-economy principles (SDG12), ensure that resources are utilised responsibly and produce fewer emissions (SDG13), save water, and help protect forests (SDG15). Through providing low-carbon infrastructure, jobs are created, which, in turn, boosts the economy (SDG8). Lastly, low-carbon buildings also create significant equity benefits by reducing energy poverty, improving energy access for all, and strengthening energy resilience in Cape Town.

FIGURE 10: SUSTAINABLE DEVELOPMENT GOALS

Source: World Green Building Council.

4.6.4 COST OF NET-ZERO CARBON BUILDINGS

There is already a strong business case for low-carbon developments: Research by the Green Building Council of South Africa (GBCSA) indicates that the green premium on capital for low-carbon buildings has progressively diminished over time, largely as a result of the growing maturity in the green industry (GBCSA, 2016). From 11% in 2011, the green cost premium in South Africa had decreased to 3,8% by 2019 and is projected to continue dropping as NZC buildings become the construction norm. The operating costs of NZC buildings are, of course, significantly lower than those of conventional buildings due to financial savings in utilities such as energy and water, and reduced maintenance costs because of smaller mechanical plant.

Another study, this time by Sustainable Energy Africa, explored the financial costs of the 'additional' energy-efficient and renewable-energy elements required to get a building to NZC levels. The results reveal a favourable financial case for energy efficiency across all buildings while renewable energy is still very expensive for many sectors due to the upfront capital costs. However, rapidly increasing electricity costs and declining PV costs are likely to improve the financial case for NZC new buildings.

4.6.5 CASE STUDIES

The City is playing a key role in promoting greener buildings through creating an enabling environment, providing suitable policies, and leading by example through its own building stock. Some examples are highlighted below.

4.6.5.1 MANENBERG CONTACT CENTRE

The City's Manenberg contact centre achieved a four-star Green Star SA office design rating in July 2012. The building was designed in collaboration with the community to be in sync with the social, economic and cultural context, and consists of office space, meeting rooms and cubicles, cash offices, waiting halls and breakaway courtyards. The indoor office spaces make maximum use of natural light and fresh-air circulation. Solar PV panels and wind power generate 30–40% of the energy consumed by the building.

Some of the sustainable building features include the following:

- A labour-intensive construction method was selected to create jobs, and local community members were trained and employed to construct some of the walls of the contact office using sandbags.
- The construction materials used were chosen for their ecological efficiency.
- The building services include a variable refrigerant volume (VRV) heating and cooling system, which is fully mechanically ventilated with solar water heaters.

FIGURE 11: MANENBERG CONTACT CENTRE

- The civil and landscaped areas account for 81% of the site, with approximately 3 100 m^2 of the site being landscaped with indigenous vegetation, which also helps minimise potable-water use for irrigation.
- The lighting system is powered by PV panels and wind power.
- The building is a great example of water-sensitive design, and features numerous water-saving interventions, such as efficient water fittings and fixtures, a leak-detection system and alternative water sources, including rainwater, greywater and blackwater.
- It also features street art from the community. The hanging artwork adorning the public hall space was sourced from a local artist.

4.6.5.2 ELECTRICITY SERVICES HEAD OFFICE (BLOEMHOF)

The Bloemhof building achieved a four-star Green Star SA office design rating and a five-star Green Star SA office as-built rating. The five-storey building consists mainly of offices configured around a central glazed atrium, a 200-seater auditorium, a cafeteria, an outdoor eating and recreational area, and basement parking. Its design promotes the use of natural light and maximises views to the outside with curved facades. Sun louvers protect the curtain wall glazing from heat gain, and blinds ensure that suitable lighting levels are maintained. Smart lighting controls, motion sensors and timers linked to the building management system have been installed to switch off when no motion is detected, or to adjust the lighting according to the amount of daylight coming into the building. A 100 kWp solar PV system is installed on the roof and carport, which provides approximately 156 MWh of the building's electricity needs per annum. A rooftop garden has been established using indigenous, waterwise plants that grow naturally in the area. The building design also includes a greywater recycling system to reduce potable-water use for the flushing of toilets and urinals. The filtration process is fully automated and chemical-free. All furniture, fittings, finishes and building fabric (paints, carpets, adhesives, composite wood products, sealants, etc.) were carefully selected to minimise emissions, and all timber products were either reused or certified with the Forest Stewardship Council.

FIGURE 12: ELECTRICITY SERVICES HEAD OFFICE (BLOEMHOF)

ENERGY AND CARBON THEME 2

TECHNOLOGY DISRUPTION, THE CITY'S ELECTRICITY UTILITY AND MUNICIPAL OPERATIONS

5.1 CONTEXT AND CHALLENGES – ELECTRICITY DISTRIBUTION SYSTEM OVERVIEW

Two electricity service providers operate within the municipal borders of Cape Town, namely the City's Electricity Generation and Distribution (EGD) Department, and the national power utility Eskom. Each of these entities holds an electricity distribution licence for a specific supply area in Cape Town, as shown in figure 13.

The City's distribution network is supplied from the national grid via 41 points of delivery. Main substations transform the bulk power received at voltages of 132 kV, 66 kV and 33 kV to lower voltages (11 kV) for further distribution. A total of 77 main substations and 30 switching substations service the City's supply area.

The footprint of a main substation represents the area it supplies. The boundaries created by the main substation footprints may vary over time as load is transferred to new or existing neighbouring substations. These footprints are illustrated in figure 13, along with an indication of peak load as at 2020, expressed as a percentage of firm capacity. The firm capacity of a substation is a network reliability index that relates to the substation's ability to withstand a N-1 fault condition.[5] To be able to respond to customer demand and load growth, the load at main substations should not exceed 95% of firm capacity, and network development plans should trigger interventions before this point is reached.

The reliability of the distribution grid underpins every sector of the economy. Standard definitions of grid reliability have focused on the frequency, duration and extent of power outages. The City calculates the number and frequency of electrical outages using globally accepted reliability indices. These are the system average interruption duration index (SAIDI), the system average interruption frequency index (SAIFI) and the customer average interruption duration index (CAIDI).

SAIDI is a measure of the average duration that customers are without power over a given period. The average monthly SAIDI for Cape Town in 2020[6] was 3,11 hours against a target of 3. SAIFI, in turn, is a measure of the frequency of interruptions that a customer experiences over a given period. The average monthly SAIFI for Cape Town in 2020 was 0,74 interruptions against a target of 1,3. Lastly, CAIDI represents the average duration that a customer is without power when affected by a supply interruption (i.e. the ratio between SAIDI and SAIFI). The average monthly CAIDI for Cape Town in 2020 was 4,22 hours against a target of 2,3 (City of Cape Town, 2020b).

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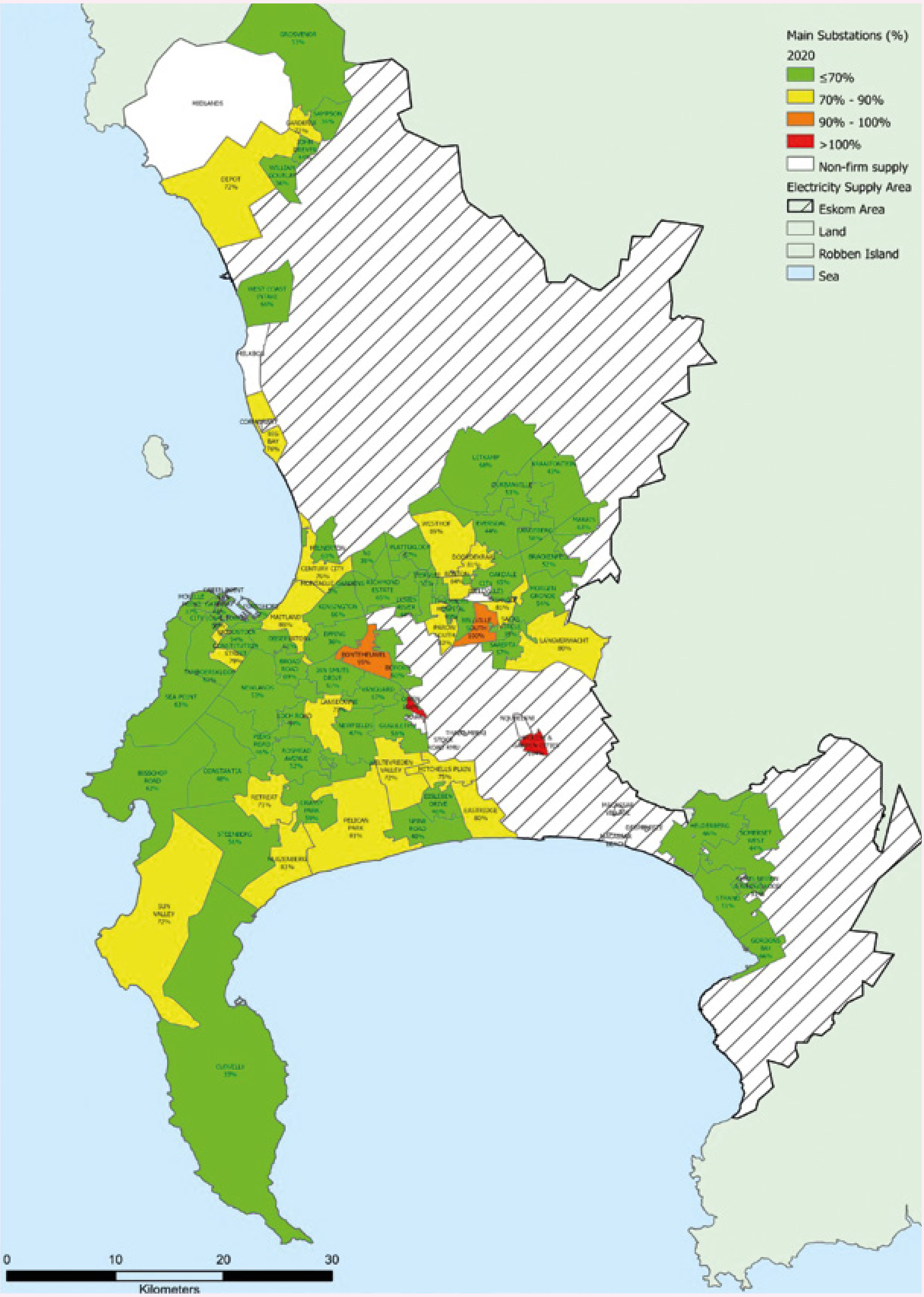
5 The N-1 criterion is satisfied if, after a single system element has failed, the system can continue to meet its minimum performance requirements.

6 The 2020 financial year (1 July 2019 – 30 June 2020).

FIGURE 13: LICENSED DISTRIBUTION SERVICE AUTHORITIES AND CCT MAIN SUBSTATION 2020 LOAD STATUS OVERVIEW



Source: City of Cape Town.

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5.2 CONTEXT AND CHALLENGES – THE STATE OF THE ELECTRICITY DISTRIBUTION INDUSTRY: REVENUE, REVENUE MODEL AND TARIFFS

Electricity services in South Africa are at a crossroads, with increasing supply constraints and load-shedding. Compounding this problem is regulatory uncertainty, which has undermined the effective management of distribution assets at the municipal level. Customers are now subjected to above-inflation tariff increases, while being exposed to supply interruptions as well.

National Government is responsible for ensuring the supply and transmission of electricity across the country. Eskom, as the national power utility, is responsible for about 95% of all electricity generated, and for all transmission of electric power in the country. And as a sphere of government, municipalities are responsible for distributing electricity to consumers. The regulated margin on sales provides municipalities with a major source of revenue, which can be used to fund other municipal functions. However, in certain municipalities, some customers are supplied directly by Eskom for historical reasons (GIZ, 2017b). This can have serious implications for municipal revenues and the management of municipal debt.

This shared Eskom/municipal role in the distribution of electricity has caused complexities in some municipalities. Different areas within the municipal jurisdiction are serviced by different service providers, with different tariff structures, and revenues going to different entities. The City is one such example. This has created multiple problems for municipalities, including a reduced balance sheet, and problems with managing outstanding debt. It has also created confusion among customers in terms of who is accountable for electrical services.

Attempts to resolve this issue have centred on regionalising the distribution of electricity. Government's initial plan was to establish six regional electricity distributors to take over the assets and functions of both Eskom and municipal distributors (National Treasury, 2011). This, however, was subsequently abandoned. Due to the uncertainty created by the proposed restructuring of the electricity distribution industry, many municipalities neglected the required maintenance and capital investment in their infrastructure, in anticipation that these assets would be transferred to another entity. This, in turn, has raised the risk of power outages.

Electricity is a major source of both municipal revenue and expenditure. There is substantial scope for municipalities to generate surpluses from their electricity operations, provided that prices are affordable. However, South Africa, including Cape Town, has been facing steep annual increases in electricity tariffs over the past decade due to the current market structure and the need for Eskom to finance its debt. Electricity tariffs are regulated by NERSA, who reviews the generation tariffs Eskom may charge for bulk electricity sales, as well as the retail tariffs municipalities and Eskom may charge. Any increases beyond NERSA's guidelines must be strongly motivated.

In 2010, NERSA announced a new system of inclining block tariffs. These tariffs divide charges into energy blocks based on the amount of electricity consumed. The tariffs for higher-use blocks include a surplus, which is then used to cross-subsidise tariffs in the lower-use blocks. This tariff structure was intended to be pro-poor, with lower tariff increases for lower-use blocks. One of the problems with this tariff, however, is that low-use customers targeted for cross-subsidisation do not always correlate with the poor households who are most in need of relief from rising electricity prices. A case in point is where several poor households are supplied from one connection. The inclining block tariff also obscures the actual cost of service for any of the customer blocks.

It is widely recognised that the recovery of fixed costs for electricity distribution through an energy tariff in an environment of decreasing sales is not optimal. This would require an increase in energy tariffs, resulting in upward pressure on prices, which, prior to 2011, was overcome by levying a fixed monthly service charge for some residential customers. However, with the introduction of inclining block tariffs in 2011, the service charge was discontinued, and municipal revenue became primarily dependent on energy sales. Since the 2008/09 financial year, electricity sales have consistently declined, with an adverse effect on municipal revenue. To address this problem, the City introduced the Home User Tariff with a service charge in 2016/17. Implementation of this tariff only started in the 2018/19 financial year, with a reduced service charge to facilitate affordable implementation. Yet the service charge still does not fully reflect the fixed costs of providing the service.

There is scope to increase revenue to municipalities by reducing losses in the distribution systems. Technical losses are inevitable when higher power levels are transmitted over long distances. On the distribution side, lower power levels are transmitted over shorter distances, resulting in lower losses. The internationally accepted margin for electricity losses in distribution systems is 3,5% – a benchmark very few cities in South Africa achieve.

With upward pressure on electricity prices and decreasing electricity sales, municipalities are being forced to rethink their business models to ensure sustainability. This has culminated in a portfolio of energy service offerings from utilities. These services tend to centre on distributed renewable-energy provision and energy efficiency, including customer-to-customer energy trading.

5.3 CONTEXT AND CHALLENGES – THE GLOBAL TRANSITION OF ELECTRICITY UTILITIES

Over the past three decades, electricity utilities have gone through a phased transition from liberalisation of the sector (GIZ, 2017a), to decarbonisation and decentralisation, to digitisation.

The liberalisation phase involved four key reforms to the traditional utility model. Firstly, utilities were corporatised to be able to function as fully fledged businesses. Barriers to entry were removed to enable competition in the sector. The monopolistic and competitive components of the business were also structurally separated, and government retained ownership of the monopolistic components. The transmission and distribution functions were widely regarded as natural monopolies, as it was not feasible to have multiple firms in the same location installing, and competing for the provision of, electrical network services. However, the generation business function was open to competition. The goal of liberalisation was to reduce the cost of electricity through competition, and to improve the quality of services to customers.

The second transition phase – decarbonisation and decentralisation – is linked to the acknowledgement of climate change and global warming as a mounting crisis over the past decade. Switching from fossil fuels to clean energy sources for energy production is considered essential to mitigate global warming. One pathway for this transition, which used to be heavily subsidised in developed economies, involves the use of embedded renewable-energy sources, which can be designed as small modular units and distributed throughout the network. This has led to the global trend of self-generation and self-consumption of electricity. Electricity consumers can now sell excess power from self-generation back to the grid, which has led to the concept of a 'prosumer' (i.e. an individual who both produces and consumes) (GIZ, 2017b).

Thirdly, utilities need to digitise their offering and provide customers with access to online services. This also involves the provision of internet-based platforms for energy trading, including customer-to-customer trading in prosumer communities.

However, the transition of the electricity sector in South Africa has not followed the global trend outlined above. In 2011, the Department of Mineral Resources and Energy (DMRE) launched the REIPPPP, a competitive procurement programme for renewable energy. This was the first step towards decarbonisation and decentralisation in the electricity sector. In addition, Eskom is currently embarking on a restructuring process. The final outcome of this exercise and its effect on electricity markets remain unclear. In the meantime, many municipalities, including the City, are independently pursuing decarbonisation and decentralisation of their electricity supply options. The City has embarked on a programme to procure electricity from IPPs, subject to relevant legislation, and has also developed regulations on small-scale embedded generation and export (feed-in) tariffs for prosumers in a 'net billing'[7] arrangement.

7 Customers are compensated at an export rate that is lower than the import rate, but must remain net consumers.

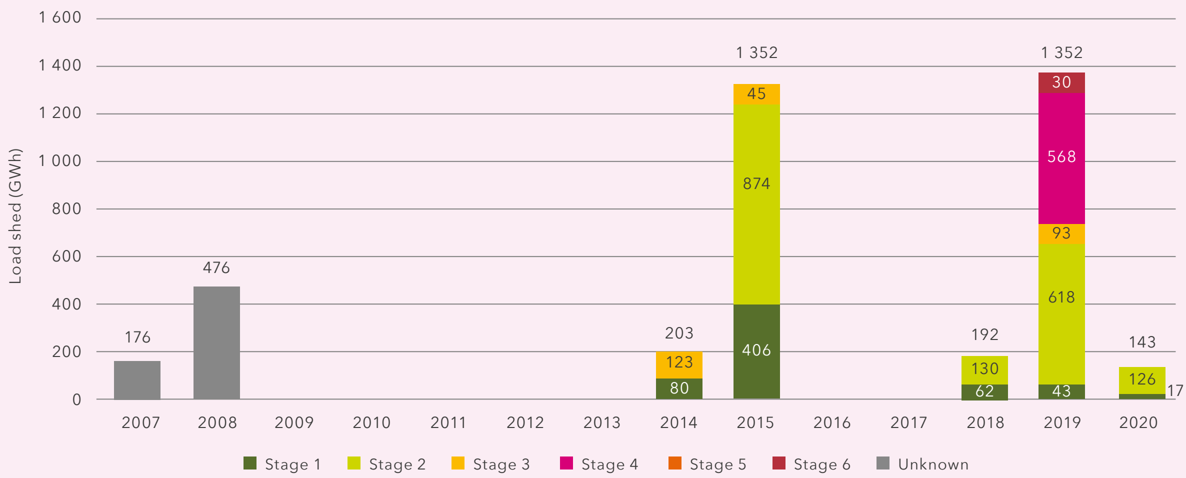
5.4 CONTEXT AND CHALLENGES – LOAD-SHEDDING: ITS ECONOMIC IMPACTS AND ENERGY SECURITY

5.4.1 LOAD-SHEDDING – A BRIEF HISTORY

Load-shedding is the rotational disconnection of loads by Eskom when generation capacity is insufficient to meet demand, so as to prevent a complete collapse of the electrical grid. This is achieved through the systematic, forced reduction of demand in blocks of 1 000 MW, referred to as a load-shedding stage. Therefore, stage 1 equals 1 000 MW 'shed', stage 2 equals 2 000 MW 'shed', etc. In essence, the consistent shortfalls in supply are due to ageing infrastructure, the suspension of maintenance practices, and historical failures in planning and in the implementation of plans to build new generation to meet the country's demand.

Prior to 2007, a long period of oversupply and cheap coal meant interruptions were infrequent, and electricity prices were among the lowest in the world. In the past five years, however, load-shedding has become far more prevalent and pervasive, as shown in figure 14 and table 2.

FIGURE 14: AMOUNT OF ELECTRICITY LOAD SHED NATIONALLY



Source: Wright J, 2020.

TABLE 2: ESTIMATED DIRECT COST OF LOAD-SHEDDING FOR CAPE TOWN

Cape Town load-shedding – general[1]			Cape Town load-shedding – industrial[2]	
Year	kWh shed	Implied cost to local economy*	kWh shed	Implied cost to local economy*
2015	52 136 000	R4 561 900 000	21 682 498	R2 168 249 800
2016	0	R0	0	R0
2017	0	R0	0	R0
2018	4 990 000	R436 625 000	2 347 885	R234 788 500
2019	83 124 000	R7 273 350 000	35 985 249	R3 598 524 900
2020	65 192 000	R5 704 300 000	28 222 298	R2 822 229 800

1 Utilising the Council for Scientific and Industrial Research's COUE value of R87,50/kWh.
2 Utilising the City's estimated industrial COUE value of R100/kWh.
* Utilising the City's estimated industrial COUE applied only to large power-use customers.

5.4.2 COST OF LOAD-SHEDDING/COST OF UNSERVED ENERGY (COUE)

Apart from the inconvenience caused by load-shedding, it also has a direct economic impact on the country. A widely accepted methodology for estimating this is the cost of unserved energy (COUE), which is defined as "the value (in rand per kWh) placed on a unit of electricity not supplied due to an unplanned interruption of a short duration (less than three hours). Thus, the COUE approach assumes that businesses and households experience the outages as irregular and of low likelihood and short duration (less than three hours) and, therefore, little or no mitigation is possible or feasible" (Eskom, 2015).

Although the COUE model is robust and repeatable, and aligned with global best practice, it may not be strictly relevant in an environment where load-shedding is increasingly prevalent because mitigation options become more feasible. Even if the electricity is not replaced by an alternative source, if the load-shedding is scheduled and predictable, it may allow shifts in production times and other adaptations, even in households. Although undoubtedly a massive drain on South Africa's economy, the direct costs quantified in table 2 have likely been somewhat mitigated by the systematic staging, rotation and communication of the outages, as well as increasing demand-side measures as outages have become more regular. Given, however, the severe indirect consequences of supply constraints, particularly the deferment or withdrawal of investment in new job-creating projects, COUE may be considered a rough measure of the actual impact of systematically staged, regular load-shedding on the economy – both locally and nationally.

Supply interruptions are mitigated to some degree by the City's generation assets – Steenbras pumped storage scheme with a total generation capacity of 172 MW, and the Roggebaai and Athlone gas turbines with a capacity of 42 and 36 MW respectively. Although small in relation to Cape Town's maximum demand of approximately 1 500 MW, these generation facilities nonetheless have proven highly beneficial, as they can be used to reduce the amount of load the City is required to drop during a national load-shedding event, depending on the load-shedding severity. The operation of Steenbras, and how it helps stave off load-shedding, is discussed in more detail in section 5.9.2.

5.4.3 ENERGY AND ELECTRICITY SECURITY

Energy security has long been recognised as critical to economic planning. At its most basic level, it is defined as "reliable, affordable access to all fuels and energy sources".[8] Yet policymakers and analysts increasingly rely on a multidimensional approach, and commonly use the 'four As' – availability, affordability, accessibility and acceptability – as a starting point (Cherp and Jewell, 2014). The 'acceptability' component is usually framed as environmental sustainability. The World Energy Council uses the concept of the energy trilemma to analyse the trade-offs in the energy sector. The trilemma relates to energy security in terms of reliable supply, energy equity and environmental sustainability (WEC, 2017). Another approach is to incorporate the economic, social, political and environmental aspects of energy security into an index. One index, for instance, captures environmental energy security with four of 20 indicators, namely the impact of energy on land use, water, climate change and pollution (Sovacool, 2013). Electricity security is becoming an increasingly critical component of energy security.

"Looking ahead, electricity is expected to play a bigger role in heating, cooling, and transport, as well as many digitally integrated sectors such as communication, finance and healthcare. The need for robust electricity security measures will become a prerequisite for the proper functioning of modern economies. All this puts electricity security higher than ever on the energy policy agenda." (IEA, 2020b)

The City is almost totally dependent on Eskom for electricity supply, and on national grants for electrification. Therefore, given load-shedding, rapidly increasing electricity prices, the very high carbon content of grid electricity, and the high levels of debt plaguing both Eskom and the national fiscus, all aspects of energy security, by whatever definition, are threatened. This exposes Cape Town's economy and social fabric to a number of risks. The City's response to these risks is summarised in the remaining sections of this chapter.

8 https://www.iea.org/topics/energy-security.

5.5 CONTEXT AND CHALLENGES – DROPPING ENERGY SALES AND DEMAND IN THE CONTEXT OF A GROWING NEED FOR ENERGY ACCESS

5.5.1 ELECTRICITY CONSUMPTION AND DEMAND TRENDS IN THE CITY OF CAPE TOWN SUPPLY AREA

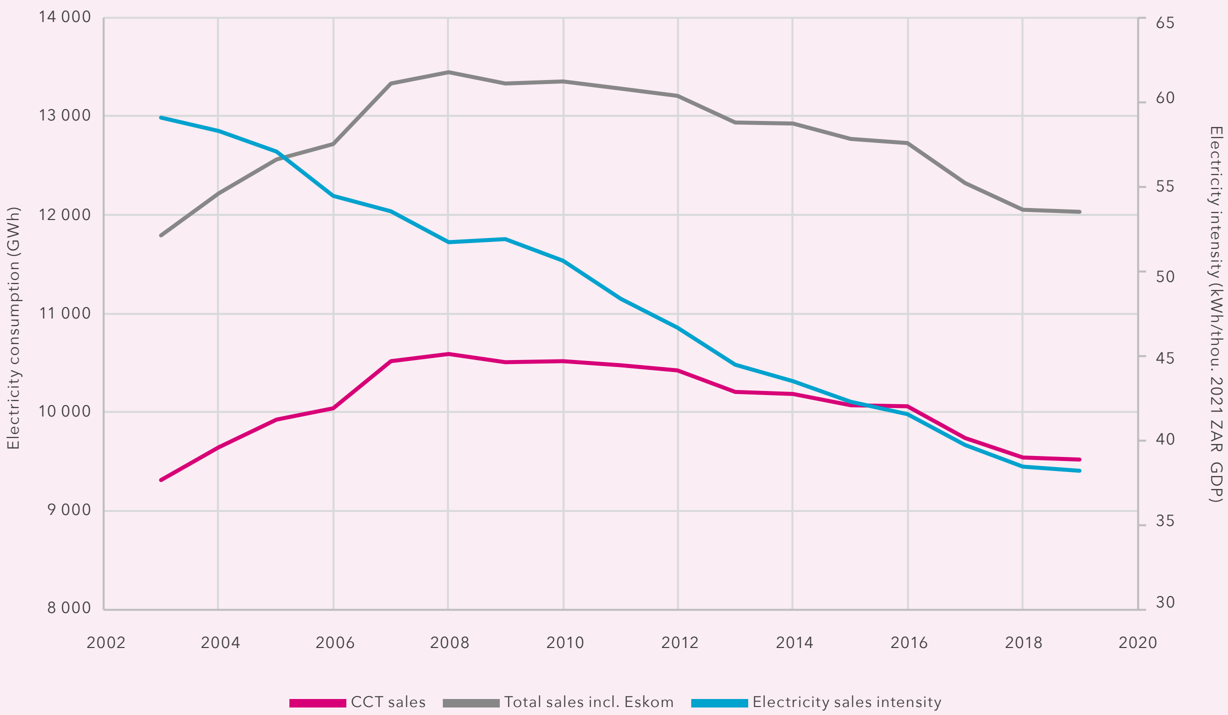
Electricity sales by utilities around the world are dropping as energy-efficient processes and appliances and self-generation are increasingly adopted by customers, often incentivised by government programmes. In developing cities like Cape Town, this is occurring simultaneously with attempts to extend services to a rapidly urbanising and often informal and poor population.

Figure 15 below shows electricity sales in Cape Town and the City of Cape Town supply area between 2003 and 2019. While the average energy growth prior to 2008 was around 3% per annum, the electricity intensity of the economy was already dropping at over 2,5% per annum. Post the economic slowdown in 2008, this has driven negative sales growth, which had dropped by 10% in total by 2019.

The negative growth trend in energy consumption is also evident in system demand as shown below. The demand growth also turned negative from an historical positive growth figure of 2,7%. Covid did not affect the 2019/20 financial year, as the slightly higher-than-expected system peak for the year occurred in July 2019, before the start of the pandemic (City of Cape Town, 2020b).

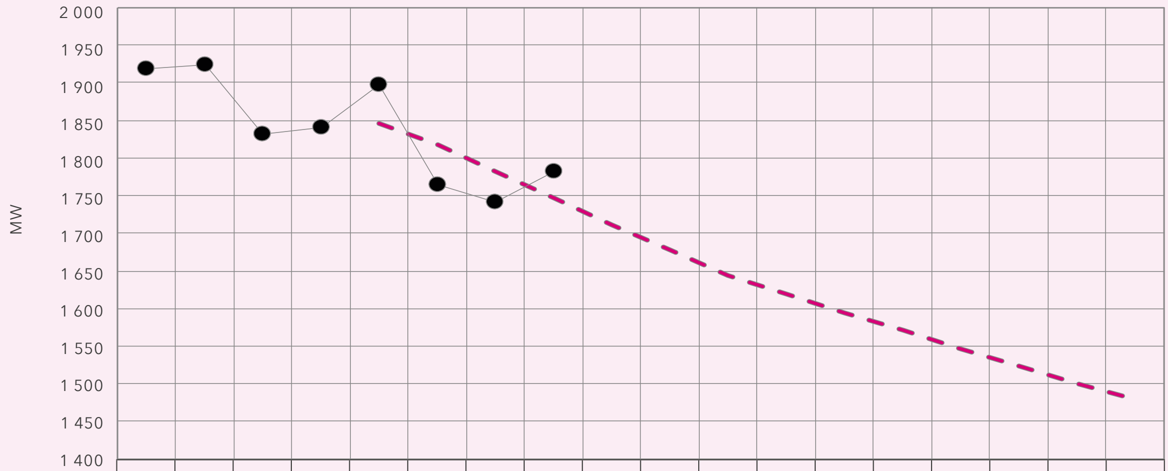
Residential energy purchases have accounted for the largest contribution to reductions in electricity sales. As shown in figure 17, the largest drop in sales in absolute and proportional terms is seen in the highest consuming (and highest income) quintile of customers which dropped at an annualised rate of over 7% between 2008 and 2019. From 2013 onwards about a third of this drop is estimated to be due to the growth of SSEG suggesting a slowing of energy-efficiency effects. The rebound in 5th quintile consumption in 2019 is more marked when adjusted for estimated SSEG production as shown above. This suggests a possible rebound in 2019 possibly due to increased hot water use as the drought eased.

FIGURE 15: TRENDS IN UTILITY ELECTRICITY SALES AND THE INTENSITY OF ELECTRICITY USE BY THE ECONOMY IN CAPE TOWN



Sources: City of Cape Town and Eskom.

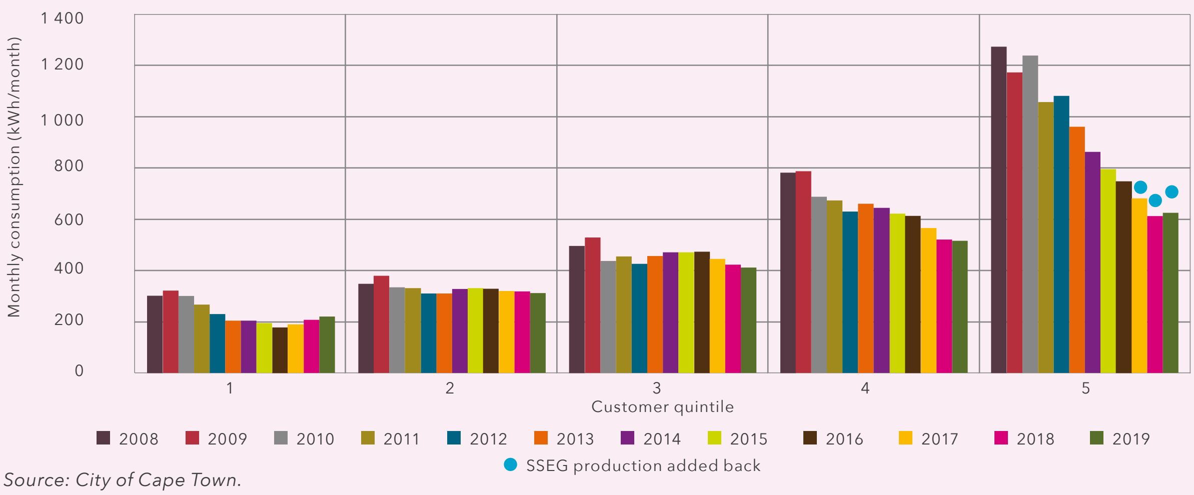
FIGURE 16: ACTUAL AND EXTRAPOLATED ELECTRICITY DEMAND IN THE CITY OF CAPE TOWN SUPPLY AREA



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast					1 846	1 818	1 782	1 746	1 711	1 677	1 643	1 619	1 594	1 570	1 547	1 524	1 501	1 478
Actual max demand	1 919	1 924	1 832	1 840	1 898	1 765	1 742	1 782										
Act/first growth	2,29%	0,26%	-4,79%	0,45%	3,14%	-6,99%	1,32%	2,30%	-2%	-2%	-2%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%	-1,50%

Source: City of Cape Town.

FIGURE 17: EVOLUTION OF RESIDENTIAL CUSTOMER CONSUMPTION BY QUINTILE



Source: City of Cape Town.

5.5.2 ENERGY POVERTY, A GROWING CHALLENGE

Households with insufficient access to energy are subject to substandard social and economic outcomes. These include adverse health effects due to exposure to cold, heat and indoor air pollution; curtailed hours of study for children in education, limited access to information, and lower productivity (OneWorld, 2019). A lack of access to clean, safe and affordable energy is also associated with gender inequality (Sustainable Energy Africa, 2016).

A growing challenge for sustainable electricity provision to all is the increasing pressure on the funding of subsidised electricity supplied to households. The pressure results from the following:

- Electricity sales have steadily declined since 2009, reducing an important source of cross-subsidisation of electricity for low-income households.
- Increasing vandalism of electricity infrastructure, and theft of both infrastructure and electricity, drive up costs.
- Low-income South Africans are rapidly urbanising, with a concomitant increase in the required level of cross-subsidisation.

Therefore, energy poverty is a complex, citywide issue that will require careful consideration as the City adapts its tariffs and business model to confront the multiple disruptions.

5.5.3 POPULATION TRENDS

The City expects Cape Town's population to expand rapidly by approximately 400 000 people between 2020 and 2025 (City of Cape Town, 2020b). Based on the population growth trends, a shift in income distribution over time is unlikely, which means that approximately 76% of all new households will be low-income (i.e. earning less than R13 000 per month) (Sustainable Energy Africa, 2016). These urbanisation trends will continue to have a significant impact on the City's expenditure in providing access to sustainable energy and other basic services.

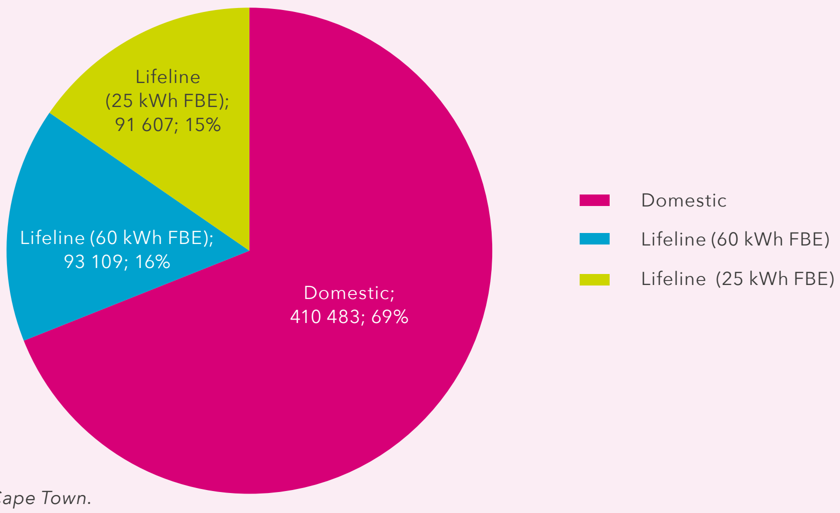
5.6 RESPONSES – THE ENERGY SOCIAL PACKAGE AND OPTIONS FOR THE FUTURE

5.6.1 FREE BASIC ELECTRICITY AND PREFERENTIAL TARIFFS

The City provides an electricity social package to qualifying low-income households. The package consists of subsidised grid connections and a subsidised (Lifeline) tariff, (City of Cape Town, 2020b) which is combined with one of two free basic electricity (FBE) allocations (City of Cape Town, 2020c) (Department of Minerals and Energy, 2003). In the Cape Town distribution area in 2018/19, 184 716[9] households received electricity at the Lifeline tariff, 93 109 at the Lifeline Block A tariff (60 kWh FBE) and 91 607 at Lifeline Block B (25 kWh FBE). In the 2019/20 financial year in the Eskom distribution area, 140 400 customers received 50 kWh per month FBE, 90 700 on the Homelight 20Amps tariff, and 49 700 on the Homelight 60Amps tariff.[10] Figure 18 indicates that for the City supply area in 2018/19, 31% of residential customers were on a subsidised Lifeline tariff, and 69% on the Domestic tariff. However, the number of electrified households in the Cape Town distribution area in 2018/19 was around 970 000, compared to approximately 660 000 who were on Residential tariffs. This is because multiple households are served by one connection, and some housing estates and apartment blocks are on commercial tariffs. Therefore, the share of subsidised electrified households in the City distribution area is likely to be closer to 20%.

Average electricity consumption is directly linked to

FIGURE 18: TOTAL NUMBER OF RESIDENTIAL CUSTOMERS ON AN ELECTRICITY SOCIAL PACKAGE TARIFF (LIFELINE) AND COST-RECOVERING (DOMESTIC) TARIFFS, 2018/19



Source: City of Cape Town.

affordability, which can have drivers other than retail price. Backyarder residents, for example, may be exploited by landlords who charge excessive rates for the on-selling of electricity, although this is illegal (OneWorld, 2019). Many low-income households in Cape Town rely on an 'energy-stacking approach' to supplement the FBE allocation, alternating between electricity and alternative energy sources (gas, paraffin, candles) to meet their daily energy needs (OneWorld, 2019). The use of paraffin and candles exposes households to poor indoor air quality, the risk of child paraffin ingestion, and fire. Energy poverty, therefore, takes on different forms, including accessibility, reliability, safety and affordability, and is not only about a lack of service or choice.

The City's Lifeline customers[11] consume an average of 228 kWh per month compared to 478 kWh for other domestic customers.[12] Table 3 below shows the average consumption in the two Lifeline customer groups and the extent to which social support reduces the relative cost.

The combination of FBE and Lifeline tariffs has also significantly protected low-income customers from real electricity price (adjusted for inflation) increases over time as shown below.

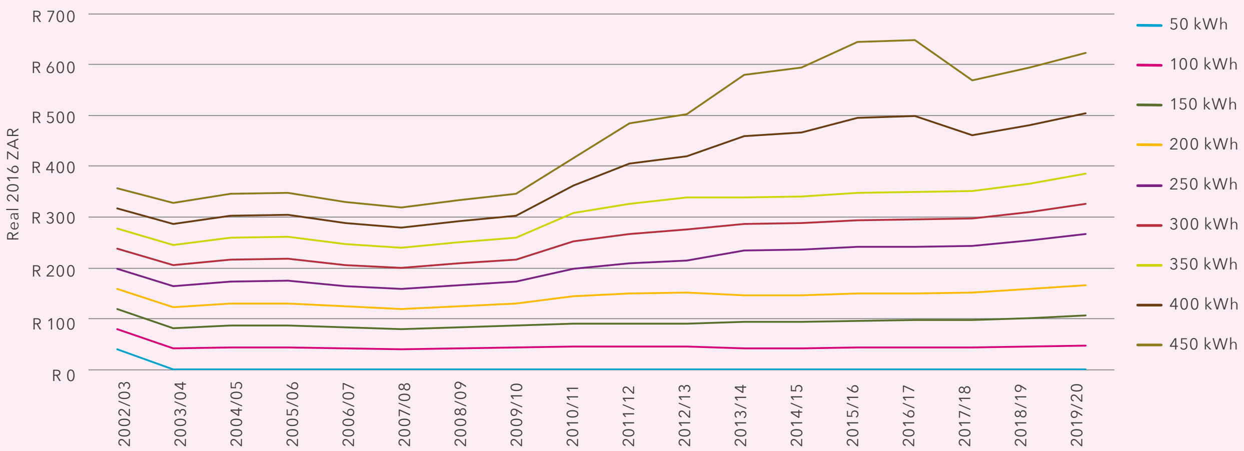
Although Cape Town is 98% (Western Cape Government, 2017) electrified (based on the 2016 community survey), an estimated 10 000[13] households in informal dwellings cannot be provided with electricity from the grid, have no access to any energy subsidy, and are the most vulnerable to energy poverty and its effects. These informal dwellings cannot be electrified because they are typically located on land that is reserved for infrastructure expansion, unsuitable or unsafe for development, or legally disputed.

TABLE 3: AVERAGE MONTHLY EXPENDITURE AND CONSUMPTION PER CUSTOMER FOR LIFELINE AND DOMESTIC CUSTOMERS, 2018/19

	Expenditure (ZAR per month)	Consumption (kWh/month)	Average cost (R/kWh)
Domestic customers	935	478	1,96
Lifeline (60 kWh FBE) customers	135	174	0,78
Lifeline (25 kWh FBE) customers	308	283	1,09

Source: City of Cape Town.

FIGURE 19: COST OF ELECTRICITY TO HOUSEHOLDS ON THE LIFELINE TARIFF FOR INCREASING MONTHLY CONSUMPTION SINCE INTRODUCTION IN 2003



Source: City of Cape Town.

9 Customer tariff allocations are reviewed annually, but can be adjusted sooner if a customer's consumption far exceeds the limit. Therefore, the number of customers on the Lifeline tariff varies throughout the year.
10 These numbers are based on the contract between the City and Eskom for the 2019/20 fiscal year.
11 Customers are sorted annually, but may be moved to the next tariff monthly if a customer far exceeds the limit.
12 Electricity Generation and Distribution Department sales data 2018/19.
13 2019/20 City and Eskom supply areas.

5.6.2 THE ESTABLISHMENT OF THE LOW-INCOME ENERGY SERVICES (LINES) UNIT

In 2017, the City established the Low-Income Energy Services (LINES) Unit. LINES forms part of the Sustainable Energy Markets Department and drives innovation in the sustainable provision of the best possible energy services to low-income households. LINES aims to improve the quality of life and socioeconomic position of low-income households by facilitating the provision of cleaner, safer energy that offers choice and flexibility, stimulating inclusivity through addressing inefficient energy use, and driving education and communication campaigns regarding energy choices and practices.

5.6.3 HISTORICAL ENERGY POVERTY RELIEF INTERVENTIONS

Below is a brief outline of interventions undertaken by the City to address energy poverty among low-income households to date:

- **Solar water heaters (SWHs):** Previous installations include 2 300 SWHs in Kuyasa (grant funding from the Department of Environmental Affairs' national SWH social programme), and 1 500 SWHs in Joe Slovo (funding from the Danida urban environmental management programme) between 2008 and 2010.
- **Solar lighting kits and Wonderbags:**[14] In 2018, the City distributed 380 solar kits (each including three lights and a cellphone charging facility) and Wonderbags to low-income households in the areas of Haasendal, Goliath, Gxagxa and Dassenberg.
- **Ceiling retrofit (2008–2017):** The ceiling retrofit project in Cape Town to date has seen the retrofit of 240 homes in Mamre, 2 300 in Kuyasa and 8 001 in various areas in Gordon's Bay, Macassar, Wesbank, Sir Lowry's Pass Village and Chris Nissen Village. A larger, multi-community roll-out will be implemented once funding is secured.
- **Knowledge sharing:** LINES hosted task team meetings as a platform to share knowledge and promote collaboration in this field. The approximately seven meetings held between 2014 and 2018 were attended by non-governmental organisations (NGOs), academics and practitioners.

5.6.4 KEY CONSIDERATIONS – MOVING FORWARD

Despite the provision of subsidised grid connections and monthly FBE allocations, the basic energy needs of the poor in Cape Town are still not being met adequately. Long-term financial sustainability is the crux to addressing energy poverty and requires a multidimensional approach. Since its inception, LINES has collaborated with various institutions and stakeholders to investigate low-income households' energy practices, and the financial implications and economic cost/benefit of energy supply and use options. The most significant findings of these studies are discussed below, together with the proposed courses of action moving forward.

5.6.5 250 KWH STUDY

This investigation set out to establish a monthly average electricity consumption that would provide low-income households with a minimum quantity of electricity, taking into account a cross-section of energy needs. Based on a desktop survey of local and international benchmarks (IEA, 2019a), it was estimated that 250 kWh per month would be a reasonable benchmark for minimally sufficient household energy supply. This would cover basic lighting, a small fridge, some stovetop cooking, some media and kettle water heating, but would exclude space heating, a geyser and oven use. This 250 kWh is far higher than the 25, 50 or 60 kWh monthly FBE allocation available to poor households.

As seen from figure 17, the average consumption of the first and second quintiles of customers is around the 250 kWh benchmark. The distribution of demand within customers on the Lifeline tariff indicates that over 60% consume less than 250 kWh and 25% less than 150 kWh monthly with the implication that many households are effectively in energy poverty whatever the benchmark. As receiving subsidy requires indigent registration, effectively a means test, a further large non-qualifying group consume close to the poverty level and struggle to consume more being fully exposed to price increases. An increased subsidy and further stratification of tariffs might bring all customers above the 250 kWh level but with current net subsidy costs increasing due to population growth and urbanisation, this does not appear possible at present. Ultimately, cheaper electricity, economic recovery and a higher rate of employment will be required to solve energy poverty completely.

5.6.6 FINANCE AND ECONOMIC STUDY

In 2018/19, OneWorld Sustainable Investments conducted a finance and economic study funded by the Agence française de développement (AFD). The study included a review of the current electricity revenue and subsidy system, analysis of the cost of supply of energy, financial modelling, and risk and cost-benefit analysis of preferred scenarios. Options and solutions were framed using an "energy services conceptual framework" (OneWorld, 2020).

The study identified a need for solutions relating to the following four foundational pillars of the long-term sustainable eradication of energy poverty:

- Partnerships between the City and the private sector are essential to provide safe and adequate alternative energy services.
- Awareness programmes need to include the hazards of unsafe energy sources, as well as the benefits of alternative energy sources to influence people to change their behaviour and energy practices. However, awareness alone will not bring about behaviour change, and programmes with incentive structures will be required.
- Education is required on the operation and maintenance of alternative energy technologies, and sustainable business models to support their uptake.
- Encouraging energy and thermal efficiency can save households money, and shifting electricity use to outside peak periods would reduce the cost of energy purchases for the City.

14 A simple yet revolutionary non-electric slow cooker.

5.6.7 POSSIBLE INTERVENTIONS GOING FORWARD

LINES has identified the following as the areas with the most potential to help the City reduce energy poverty in financially and environmentally sustainable ways:

- The provision of LPG as a cleaner and more sustainable energy source
- The deployment of SWHs in formal households, with the DMRE's SWH programme being an opportunity not to be missed
- Promoting and facilitating the thermal efficiency of homes, including installing ceilings where houses do not have any
- The shifting of electricity consumption to outside peak periods (it is recognised that this is not readily achievable in low-income households, however, so innovative solutions such as cost-effective energy storage will be required)
- The provision of small (50–75 Wp) off-grid solar home systems, either individually or through 'mini-grids', to households not connected to the grid
- Electricity Lifeline tariff optimisation to circumvent disincentives for increased consumption
- Education and awareness that empowers residents to make good choices, covering topics such as safety, subsidies, energy efficiency, fuel choices, and the longevity and running costs of energy devices
- Further studies to understand current energy-stacking practices, including the drivers of residents' choices, purchase patterns, usage patterns and, importantly, cultural and social perceptions of various energy options. Another area of interest is the effect of the introduction of LPG into the household energy mix on electricity purchases and time-of-use patterns.

5.6.8 CONCLUSION

There is no 'one size fits all' solution to the very complex issue of energy poverty. Diversifying energy services to include alternative energy sources is vital in the current context of uncertainty as to the affordability and sustainability of electricity. (Electricity prices will likely continue to rise and higher-income customers will likely defect from the grid.) Obtaining quality primary data concerning low-income household energy use, perceptions and practices will be crucial when considering interventions.

5.7 RESPONSES – WHERE THE CITY'S UTILITY COULD GO, HOW WE ARE PLACED, AND WHAT WILL BE NEEDED TO MANAGE OUR TRANSITION

While the City is the service authority for the entire metro, two service providers operate in the Cape Town jurisdiction, namely the City's EGD Department and Eskom. Each provider holds a NERSA-issued electricity distribution licence for a supply area. EGD is the same legal entity as the City, even though it is operated as a financially ring-fenced department.

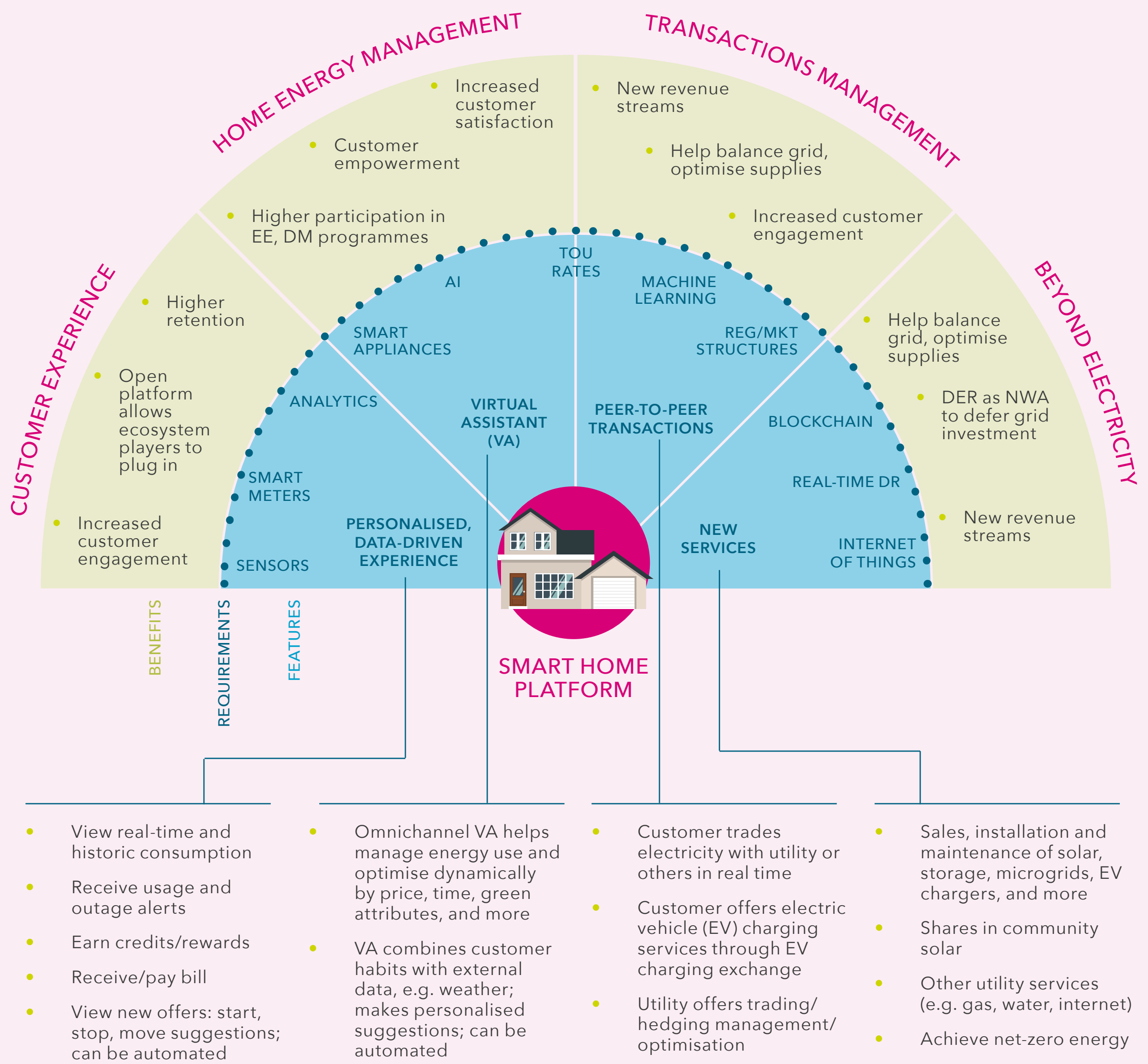
The City's distribution network includes 41 major injection points from the national grid. Current generation assets are limited to two small gas turbines (Athlone and Roggebaai), which are usually run in emergencies only, and the Steenbras pumped storage plant, which is of considerable strategic importance for mitigating load-shedding, and for load-shifting applications. The large generating assets in the province – the nuclear power station Koeberg and the gas turbines Ankerlig and Gourikwa – are Eskom-owned. It is widely recognised that the electricity systems of the future will be more decentralised, and the City has committed to move towards carbon neutrality faster than required by current national policy. However, moving to a zero-carbon, decentralised system, while still expanding energy access and reducing energy poverty, involves many technical, social and planning challenges.

The upsides of a more modernised electricity sector locally include lower overall cost of supply, job creation through a more distributed and diversified power generation mix, and a stronger role for demand-response market mechanisms. Inverter-based grids are proving challenging to control in terms of balancing supply and demand, and investment in engineering and staff is required to ensure reliability of supply.

In the medium term, the likely strategy is to steer the future business towards progressively less dependence on a central utility and central planning. A key component of this strategy is an unbundled generation entity. The City is actively pursuing a programme of purchasing power from IPPs with the proposed establishment of a City-level IPP office. The City is also exploring opening up markets at the distribution level by establishing a wheeling framework that will allow customers to purchase power directly from IPPs. Given the pressure on the revenue model and electricity prices, the retail component of the utility also needs to be unbundled to ensure distribution grid cost recovery through cost-reflective and transparent tariffs. This includes optimal green energy tariffs to protect exporting customers from trade risk or from lack of competitiveness in international supply chains, which demand low or zero-carbon goods and services (City of Cape Town, 2019c).

The foundation needs to be laid for a new energy future in the long term, in which the energy system and the way in which energy is traded will look substantially different. Customers are expected to become the focal point of the future utility, as shown in the figures below. The City will need to put in place the means for energy trading that will leverage the opportunities of 'sector coupling'. For instance, decentralised storage capacity in industrial sites and electric vehicles could be deployed and compensated when advantageous, and decentralised inverters could be contracted to supply reactive power to the grid for a margin. This would also include smart technologies for demand-side management with real-time pricing. The envisaged unbundled utility is unlikely to generate the revenues of former years, however, so the City's revenue model would simultaneously need to shift to other sources.

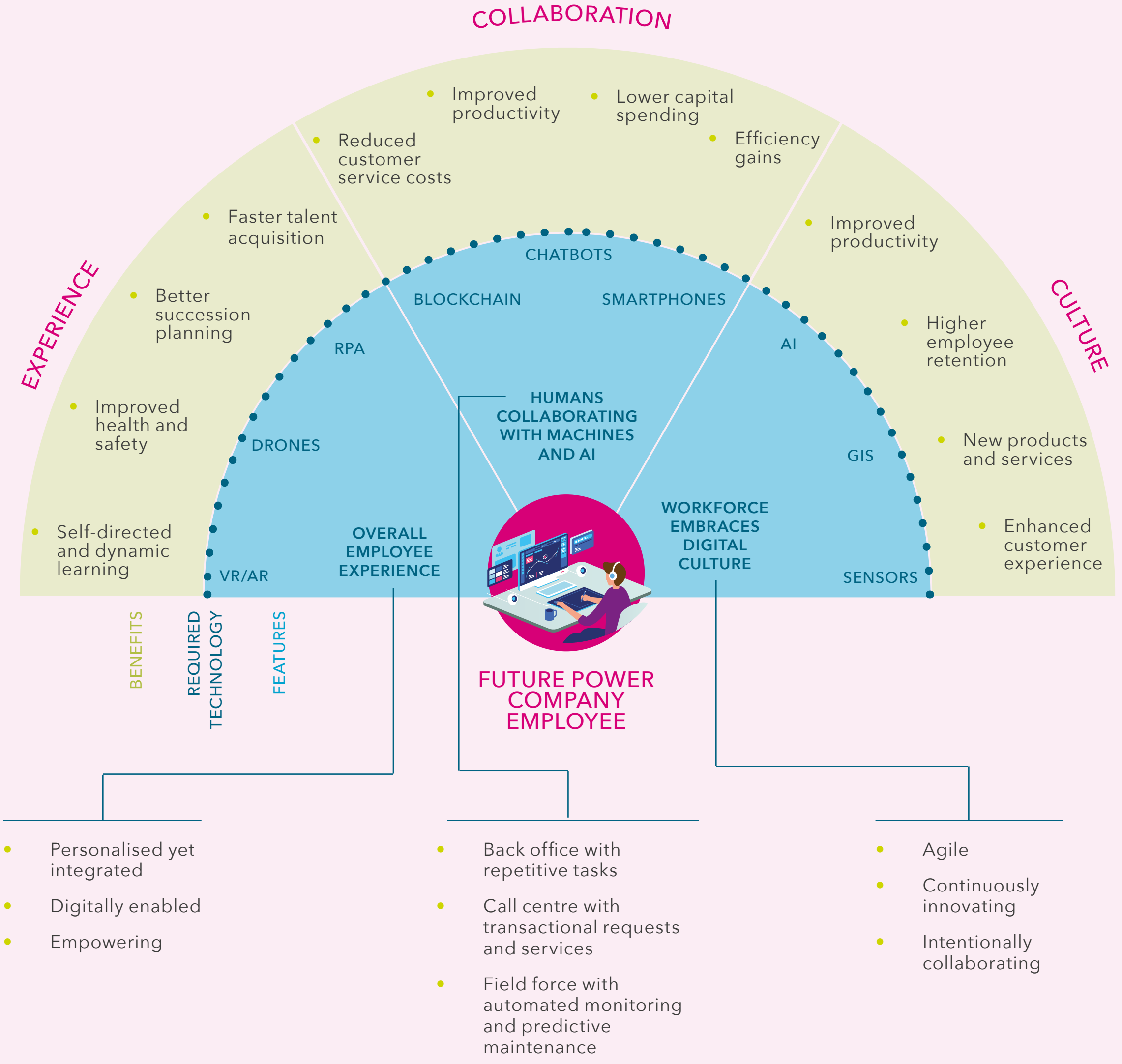
FIGURE 20: THE FUTURE UTILITY CUSTOMER



Note: DER: Distributed energy resources such as rooftop solar, storage batteries, and EV chargers; NWA: Non-wires alternatives; DSM: Demand side management; EE: Energy efficiency; DR: Demand response. Requirements listed are not comprehensive.

Source: Deloitte, 2019.

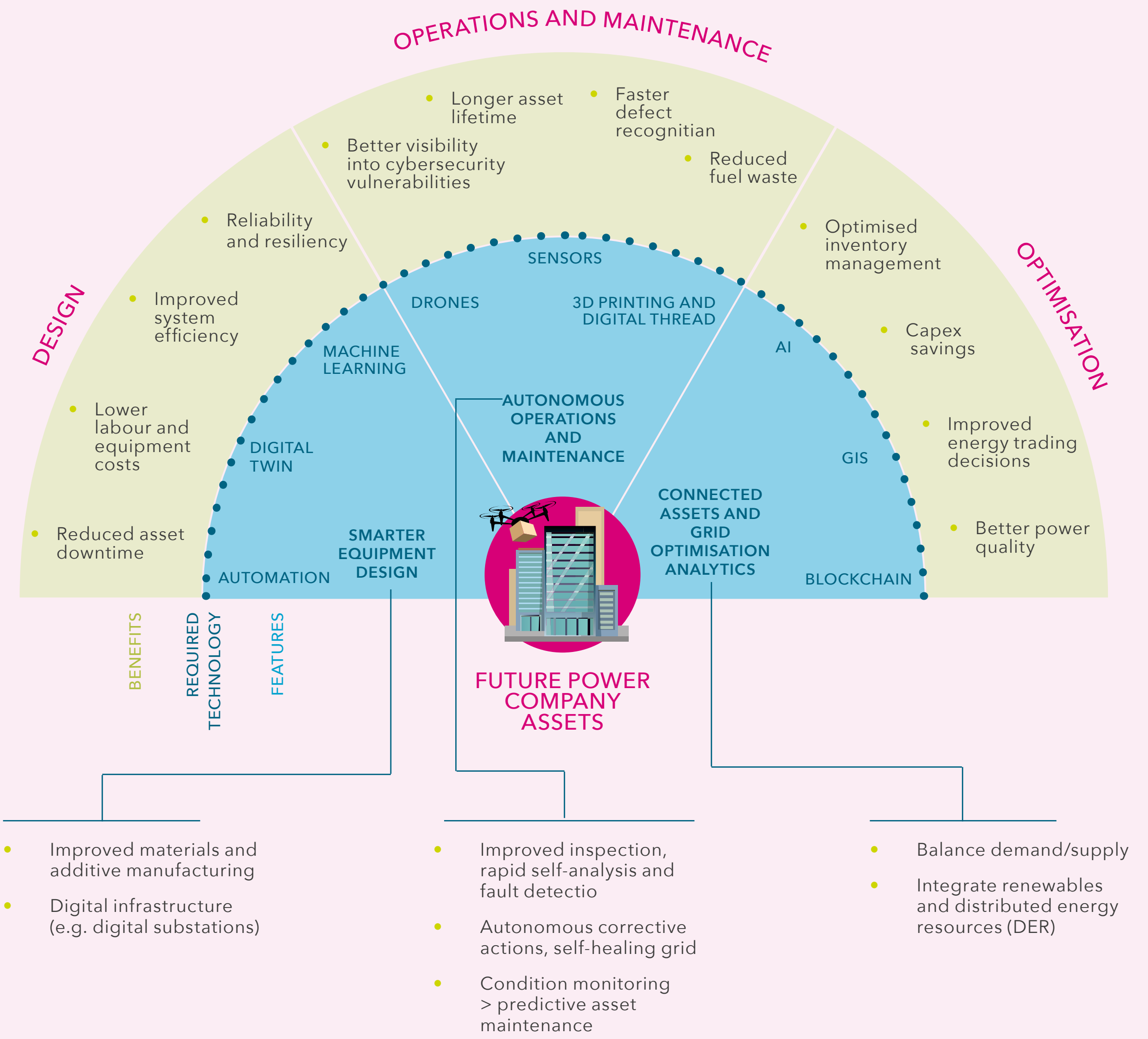
FIGURE 21: THE FUTURE UTILITY EMPLOYEE



Note: AR/VR: Virtual reality/augmented reality; RPA: Robotic process automation; AI: Artificial intelligence; GIS: Geographic information systems (mapping technology). Required technologies listed are not comprehensive.

Source: Deloitte, 2019.

FIGURE 22: THE FUTURE UTILITY



Note: Required technologies listed are not comprehensive.

Source: Deloitte, 2019.

5.8 RESPONSES – ENERGY EFFICIENCY AND DEMAND MANAGEMENT IN MUNICIPAL OPERATIONS

5.8.1 INTRODUCTION

The City provides services to over four million citizens and is Cape Town's single largest employer. In 2018, its operations accounted for the largest share of demand for energy overall (1%) and electricity (3%) by any one entity in Cape Town. Most of the City's functions have an energy implication, including bulk water supply and wastewater treatment, public lighting, public facilities, electricity services provision and waste management.

Waste and wastewater management, particularly under anaerobic conditions, generates methane, a powerful GHG. Methane capture, however, has the potential to provide energy, while mitigating substantial GHG emissions and offsetting some of the 2% share of citywide emissions generated by local government operations.

Rising electricity costs, the need to decarbonise, and national government initiatives have driven an organised programme of energy efficiency and renewable energy in City operations, which has been ongoing since 2009. At the same time, a monitoring programme has been developed to prioritise projects, verify savings and maximise benefits through the measurement of facility electricity consumption. This metering project has seen the installation of automated meter readers in 56% of facilities. The online SmartFacility application has also been developed to allow for better monitoring and tracking of the resource usage of the City's infrastructure assets, as well as better quantification of the performance of completed projects and the anticipated savings of planned projects.

Between 2009/10 and 2020/21, these projects reduced demand for electricity by 265 GWh, saved over R280 million, and avoided 262 735 tCO_2e in GHG emissions. As part of the global C40 Programme, cities like Cape Town have committed to owning, occupying and developing only NZC facilities by 2030. This commitment and the continuously rising grid electricity prices make the energy efficiency and supporting metering programme even more critical in the decade ahead.

This section provides an overview of the current state of energy in the City's municipal operations, including details of implemented projects, as well as planned projects for the immediate future.

5.8.2 LOCAL GOVERNMENT SECTOR OVERVIEW: THE STATE OF ENERGY IN LOCAL GOVERNMENT OPERATIONS

In 2018, the energy required to deliver services cost the City close to R710 million, or around 3% of the administration's non-remuneration operating budget.

The breakdown of energy demand by fuel and key service sector shows the dominance of electricity, particularly for wastewater treatment in figures 23 to 26. Significant shares of energy and emissions are also accounted for by buildings, diesel vehicles and streetlights.

TABLE 4: COST OF LOCAL GOVERNMENT ENERGY CONSUMPTION, 2018

Activity	Raw units (kWh or litres)	Energy (GJ)	Cost per unit (ZAR)	Total cost (ZAR)
Electricity	379 809 529	1 367 314	1,28	R486 156 197
Fleet: Diesel	11 674 108	444 783	12,47	R145 576 121
Fleet: Petrol	6 001 850	205 263	13,31	R79 884 623
Stationary: Diesel	1 362 947	51 928	12,47	R16 995 949
Gas turbines: Jet fuel (Athlone and Roggebaai)	142 302	4 318	8,72	R1 240 873
Total		**2 073 607**		**R729 853 764**

Source: City of Cape Town, Sustainable Energy Markets Department.

FIGURE 23: LOCAL GOVERNMENT ENERGY CONSUMPTION BY ENERGY SOURCE, 2018

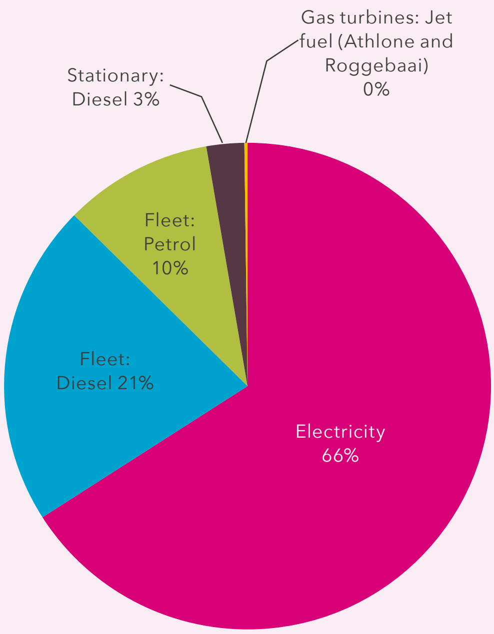


FIGURE 24: LOCAL GOVERNMENT ENERGY CONSUMPTION BY SERVICE SECTOR, 2018

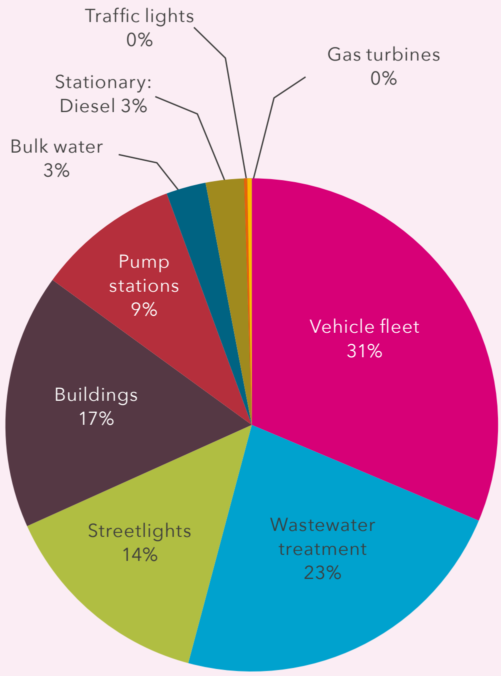


FIGURE 25: LOCAL GOVERNMENT GREENHOUSE GAS EMISSIONS BY SERVICE SECTOR, 2018

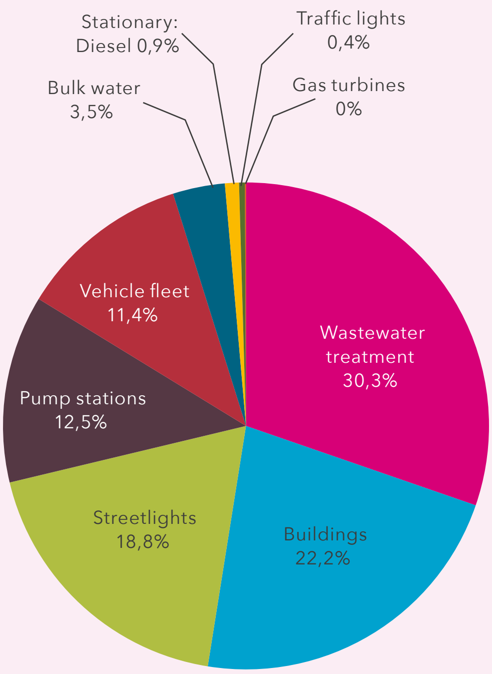
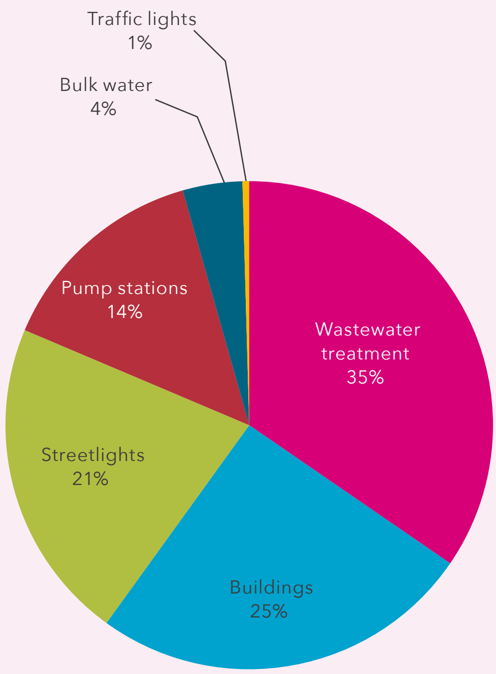


FIGURE 26: LOCAL GOVERNMENT ELECTRICITY CONSUMPTION BY SERVICE SECTOR, 2018



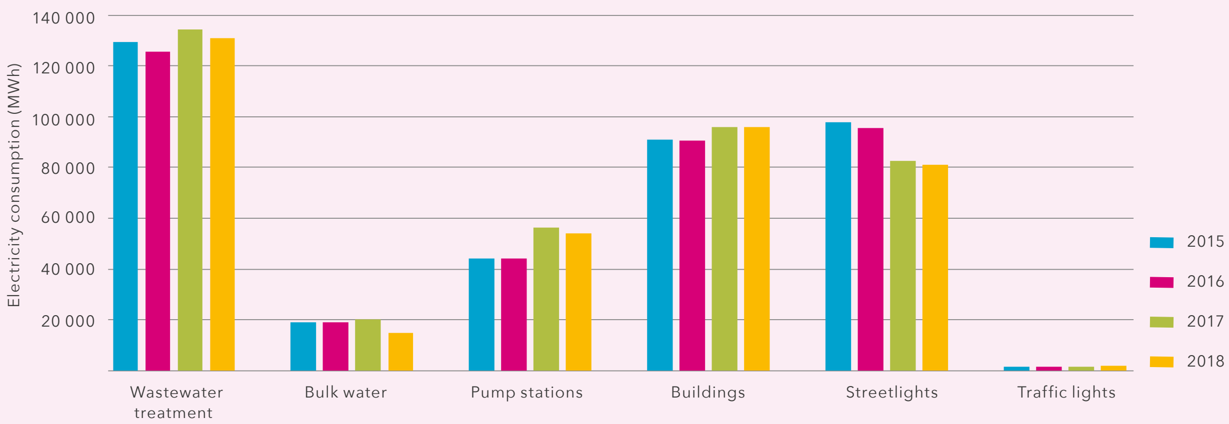
Figures 23–26 source: City of Cape Town, Sustainable Energy Markets Department.

The programmatic expansion of the metering of City facilities has improved the quality of data at the level of service sectors compared to previous editions of the State of Energy and Carbon report. The picture that is emerging now shows some of the benefits of energy-efficiency investments, particularly with regard to streetlights.

As a result, despite local government infrastructure growing along with Cape Town's population, net electricity consumption by municipal services levelled off, and then dropped by around 7% over the past 10 years in the City supply area, as shown in figure 28.

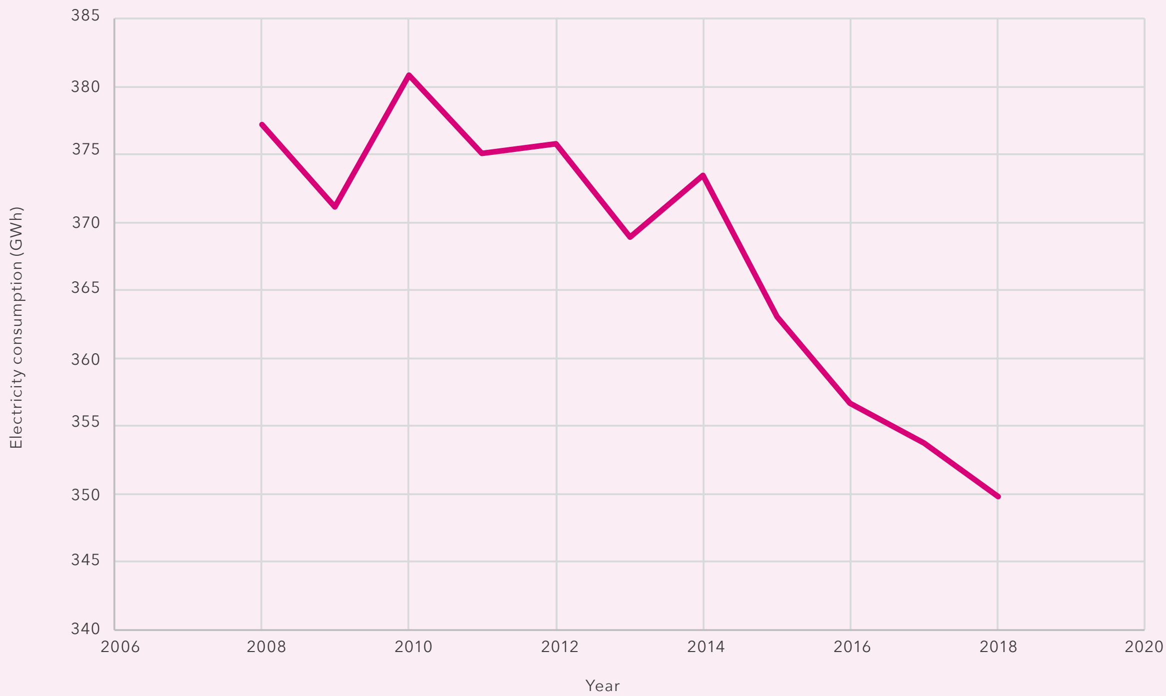
The graph in figure 29 provides a further breakdown of facilities, and of the annual electricity consumption by facility type. Most of the larger facilities are metered and monitored via automated meter infrastructure. As there is no measured data for transport and recreational facilities, these are estimated based on billing calculations.

FIGURE 27: LOCAL GOVERNMENT ELECTRICITY CONSUMPTION BY SECTOR, 2015–2018



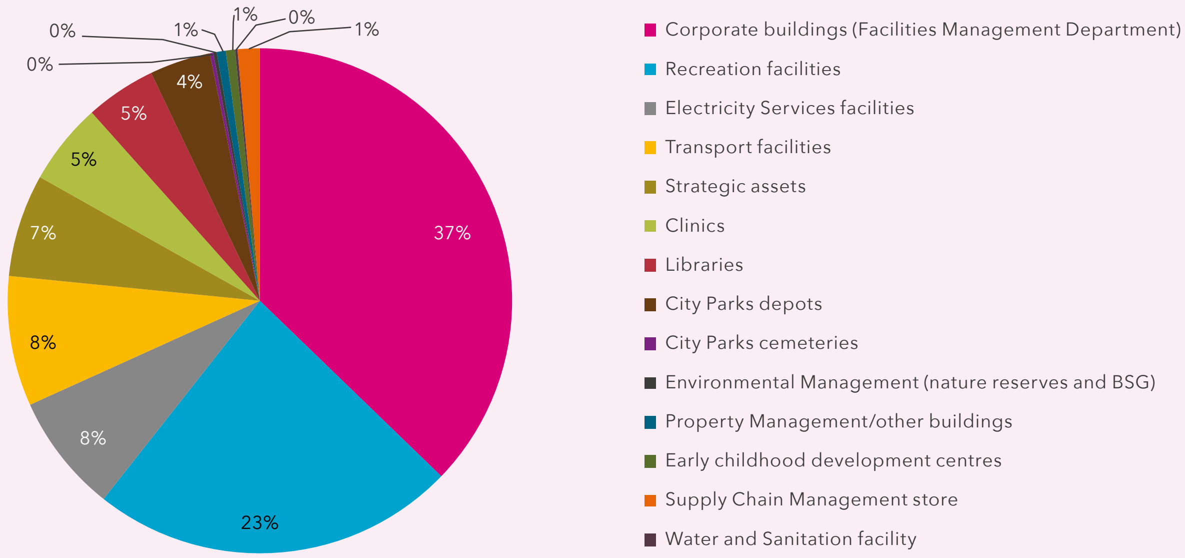
Source: City of Cape Town, Sustainable Energy Markets Department.

FIGURE 28: TREND IN ANNUAL MUNICIPAL ELECTRICITY CONSUMPTION SUPPLIED BY THE CITY OF CAPE TOWN (GWH) – 12-MONTH ROLLING AVERAGE OF BILLING DATA



Source: City of Cape Town, Sustainable Energy Markets Department.

FIGURE 29: LOCAL GOVERNMENT ELECTRICITY CONSUMPTION BY FACILITY TYPE, 2018



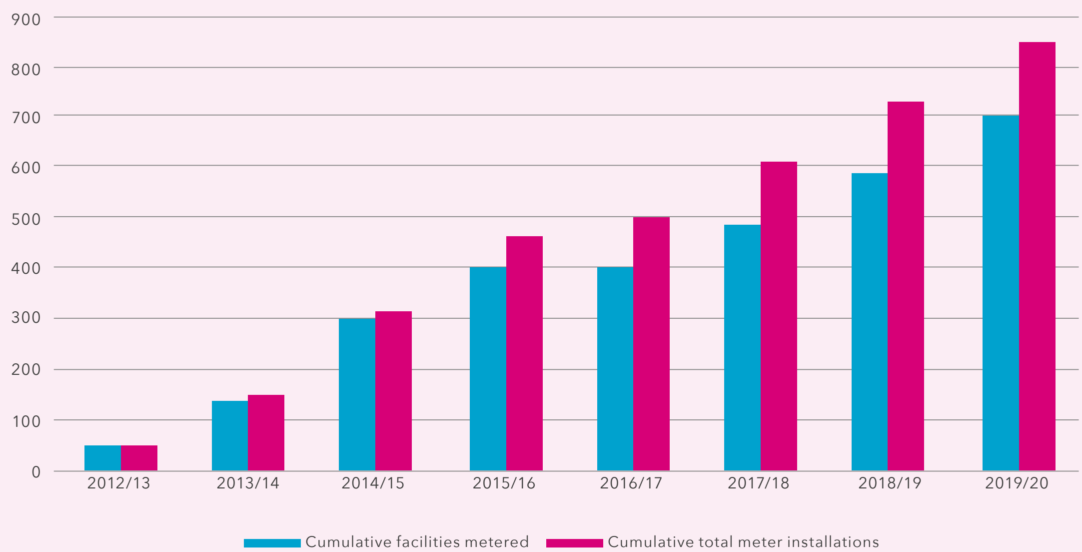
Source: City of Cape Town, Sustainable Energy Markets Department.

5.8.3 METERING AND MONITORING OF MUNICIPAL OPERATIONS

Since 2012, the City has implemented a project to install automated meter readers, or smart meters, across its 1 300 municipal facilities. These are either 'billing' meters used for (internal) billing by the utility and for monitoring, or statistical meters used only for monitoring. By the end of 2020, the project had seen the installation of 909 smart meters across 751 (56%) of the municipality's larger consuming facilities. The City plans to install the remaining meters over the next three to four years. A pilot smart water sensor device project was also initiated in 2018. The live water readings this project generates have the potential to monitor the performance of savings interventions, but also to provide early warnings of leaks.

SmartFacility is an internal, web-based visualisation and reporting application launched in 2018. Facility managers and staff on the City network can access near-live electricity and water readings of those municipal facilities that have smart devices installed. User-friendly dashboards and reports can be viewed, generated and downloaded to monitor and proactively manage high consumption and resource wastage.

FIGURE 30: PROGRESS AND STATUS OF THE MUNICIPAL FACILITY METERING PROGRAMME FROM INCEPTION UNTIL 2019/20



Source: City of Cape Town, Sustainable Energy Markets Department.

5.8.4 ENERGY EFFICIENCY AND RENEWABLE ENERGY IN MUNICIPAL OPERATIONS

ENERGY-EFFICIENCY PROJECTS SINCE 2009

The City has benefited from grant funding from the Energy-Efficiency Demand-Side Management (EEDSM) programme for roughly a decade. Initial projects that made use of the EEDSM grant focused on traffic light retrofits. Pilots in building energy-efficiency projects were also carried out with donor funding, and included T5 fluorescent lighting retrofits (from a T8/T12 inefficient fluorescent baseline), SWHs, power factor correction, and air-conditioner timers. Streetlight retrofits initially focused on replacing mercury vapour lighting with high-pressure sodium technology, and since 2016, retrofits have made use of light-emitting diode (LED) technology. Building lighting retrofit projects initially focused on installing T5 fluorescent lighting with electronic control gear (in the place of inefficient T12/T8 fluorescent lamps with electromagnetic control gear). The evolution of LED lighting and its rapid drop in price resulted in a shift to this technology from 2015 onwards. Since 2018, the use of passive infrared sensors has gradually been adopted in all lighting projects making use of digitally addressable lighting interfaces.

SUMMARY OF ENERGY-EFFICIENCY PROJECTS, SAVINGS AND PAYBACK PERIODS

The adoption of lifecycle costing in municipal infrastructure planning has highlighted the importance of energy efficiency. Lifecycle costing enables one to analyse the contributions of capital, maintenance and operational (electricity) costs over a 10 to 15-year lifespan for motors, lights, air conditioners, etc. Invariably, energy-consuming assets with a low capital cost have very low energy-efficiency ratings, while energy consuming assets with a higher capital cost yield very high energy-efficiency ratings. The focus needs to be on the fact that the asset (for instance LED lights) initially purchased at a higher capital cost requires significantly lower operational (electricity) and maintenance costs. The table below provides an overview of the City's energy-efficiency projects in its municipal operations.

TABLE 5: OVERVIEW OF ENERGY-EFFICIENCY PROJECTS IN CITY OF CAPE TOWN OPERATIONS

Theme	Action	Total actual savings (2015/16-2019/20)	Typical payback period	Implementing branch
Building and stadia efficiency	56 large City-owned building complexes and two sports stadia retrofitted since 2009	R81 million 38 575 MWh 38 675 tCO_2e	Six years	Sustainable Energy Markets Department
Traffic lights	100% LED light retrofits	R58 million 42 210 MWh 41 788 tCO_2e	Three years	Transport Directorate
Streetlighting	14% of inefficient high-intensity discharge fittings retrofitted with LED technology (total of 33 037 streetlights) R59 million investment	R61 million 59 163 MWh 58 572 tCO_2e	Nine years	Public Lighting
Metering and monitoring	909 smart meters installed at 751 facilities (includes submeters)	Accurate billing of City facilities, and provides for accurate measurement of savings	N/A	Sustainable Energy Markets and Electricity Generation and Distribution departments
Rooftop PV to offset consumption	563 kWp (kilowatt-peak) installed on City buildings (rooftop)	749 138 kWh/year R898 965/year	Nine years	Energy and Climate Change, and Urban Management directorates

Source: City of Cape Town, Sustainable Energy Markets Department.

CURRENT PROJECTS AND SAVINGS POTENTIAL

The City is considering the following energy-efficiency projects for implementation in the short to medium term:

- Continued retrofit of T8 fluorescent lighting in buildings with LED lights equipped with passive infrared sensors (making use of digitally addressable lighting interfaces)
- Continued retrofit of high-intensity discharge streetlights with LED fittings
- Installation of efficient water heating systems (heat pumps, etc.)
- Retrofit of standard-efficiency air-conditioning systems with inverter-type air conditioners
- Installation of timers on air-conditioning systems
- Installation of HVAC controls preventing simultaneous heating and cooling
- Floating head pressure control on water-cooled chiller HVAC systems
- Variable-speed drive installation on air-handling unit fans and/or chilled water pumps in HVAC systems
- Adoption of 'free' cooling and night precooling techniques, as well as investigating the feasibility of building heat-gain reduction
- Supporting Water and Sanitation Department with the adoption of the SANS50001:2019 standard for wastewater treatment

These projects are expected to achieve savings of 1 to 4 million kWh of electricity per year.

FUTURE PLANNED BUDGETS, PROJECTS, SAVINGS AND PAYBACKS

Continued access to the EEDSM grant will support the City's savings projects. Tariff optimisation for all municipal operations directly supplied by Eskom will be gradually implemented as a cost-saving measure. Table 6 demonstrates the 2020 national EEDSM budget allocations for City of Cape Town to implement energy efficiency projects.

The City also continues to utilise its own funds for energy-efficiency projects, typically to top up and ramp up implementation of projects with five-year payback periods.

FIGURE 31: PICTURES OF LIGHT-EMITTING DIODE ENERGY-EFFICIENCY PROJECTS AT CITY OF CAPE TOWN SPORTS STADIA, BUILDINGS AND STREETLIGHTS

TABLE 6: DIVISION OF REVENUE ACT (DORA) ALLOCATIONS OF EEDSM GRANT TO CITY OF CAPE TOWN FOR NEXT THREE YEARS

DORA allocations	2019/20	2020/21	2021/22	2022/23
EEDSM grant (Rm)	11,06	10	9	13

Source: City of Cape Town, Sustainable Energy Markets Department.

5.8.5 CITY-OWNED SMALL-SCALE EMBEDDED GENERATION

LOCAL GOVERNMENT ROOFTOP SOLAR PHOTOVOLTAIC INSTALLATIONS

To further supplement the City's efforts to reduce its reliance on the national electricity grid, the installation of rooftop PV systems has provided a significant amount of renewable energy. Since 2012, 10 such systems with a total capacity of 563 kWp have been installed at City facilities. In 2018, the total electricity generated by these systems amounted to approximately 850 MWh.

As the data for solar PV generation are provided on different platforms with restricted access, the systems have been fitted with statistical meters to provide PV generation readings through the online SmartFacility application.

The table below provides an overview of the PV systems currently installed.

FUTURE POTENTIAL PHOTOVOLTAIC INSTALLATIONS IN MUNICIPAL OPERATIONS

To increase the uptake of renewable energy, the City is planning an additional 14 PV installations with a total installed capacity of about 10–15 MWp. These future PV systems are a combination of ground-mounted systems at various wastewater treatment plants, and rooftop systems at electricity depots and office buildings.

TABLE 7: CITY OF CAPE TOWN SOLAR PHOTOVOLTAIC INSTALLATIONS TO DATE

No	Facility name	System size (kWp)	Commissioned
1	Royal Ascot	20	8 Feb 2016
2	Omni Forum	60	20 Jan 2016
3	Gallows Hill traffic department	10	8 Aug 2014
4	Energy headquarters stores	160	Nov 2017
5	Energy headquarters main office and carports	100	13 Feb 2014
6	Khayelitsha environmental health centre	17	27 Jun 2018
7	Kuyasa library	40	1 Oct 2015
8	Brackenfell training centre	53	17 Jun 2014
9	Electricity house building	63	1 Mar 2018
10	Manenberg housing contact centre	20	2012
11	Wallacedene taxi rank	20	1 Aug 2014
	TOTAL	**563**	

Source: City of Cape Town, Sustainable Energy Markets Department.

5.8.6 CARBON-NEUTRALITY PATHWAY TO 2030

C40 Cities partners such as Cape Town have committed to own, occupy and develop only NZC assets by 2030.

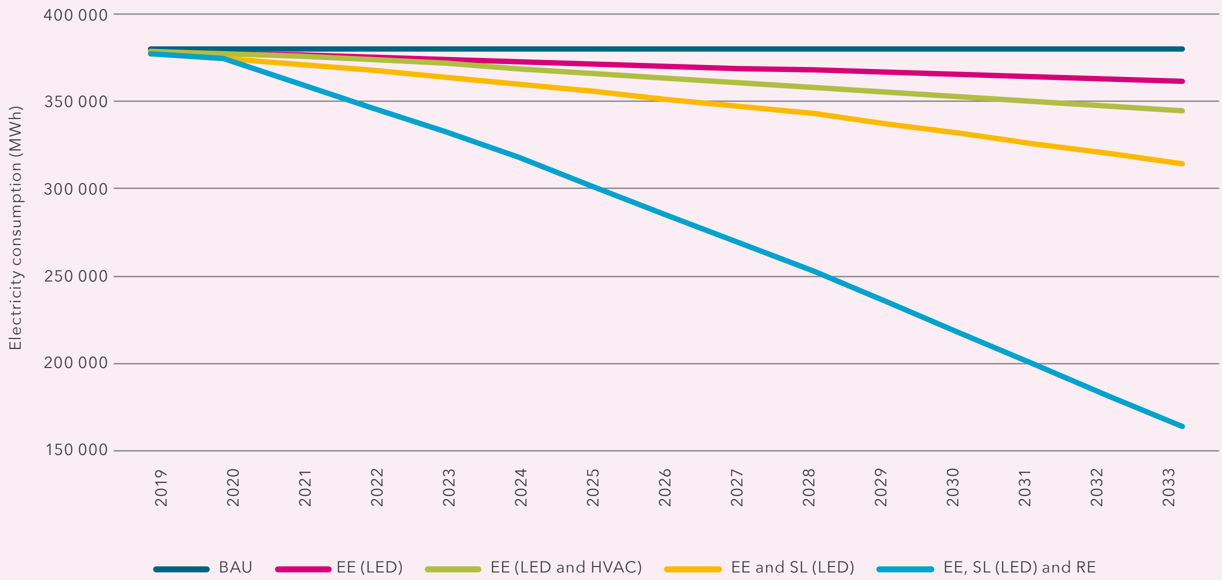
To meet this commitment, the City will:

- evaluate the current energy demand and carbon emissions from municipal buildings, and identify opportunities to improve;
- establish a roadmap demonstrating its commitment to achieve NZC buildings; and
- report annually on building performance against targets, and evaluate the feasibility of including emissions beyond operational carbon (such as refrigerants).

The low-carbon pathway shown in the figure below is broken down into the following components:

- EE (LED): LED lighting energy-efficiency retrofits expected to yield 1,25 million kWh savings per year. For 15 years, this should yield 19 million kWh savings off the 380 million kWh baseline for the City.
- EE (HVAC): In terms of HVAC efficiency projects, an estimated 1–1,25 million kWh/year savings are projected, which, by 2033, would translate into a 15–20 million kWh reduction off the 380 million kWh baseline for the City.
- Streetlight LED retrofits are likely to yield savings of 1 million kWh per year.
- The City has 650 high-mast lights. Should these be retrofitted with LED technology, the current total consumption of 22 million kWh/year will be more than halved.
- A reduction of 150 million kWh off the 380 million kWh/year actual buildings baseline would require approximately 100 MW of solar PV renewable-energy generation.

FIGURE 32: BUSINESS-AS-USUAL VERSUS ENERGY-EFFICIENT AND RENEWABLE-ENERGY OFFSETTING PATHWAY



Source: City of Cape Town, Sustainable Energy Markets Department.

5.8.7 MUNICIPAL FLEET

The City's vehicle fleet is split into the four hubs of Corporate Fleet Management, Energy and Climate Change, Solid Waste, and Water and Sanitation. Each is managed separately.

Vehicle procurement is governed by the MFMA regulations, which prohibit the targeting of specific vehicle makes. Vehicle specifications, therefore, may not be prescriptive, but must be neutral and encompass as many makes as possible.

FLEET MANAGEMENT CONSUMPTION

City vehicle fleet data were supplied by the City's Fleet Management Department in the Asset Management Directorate. Petrol and diesel volumes for the period 2007–2019 are shown in the following two graphs.

In 2018, the fleet comprised 8 707 vehicles and plant equipment. The total volume of liquid fuels used was 17 675 958 litres (petrol: 6 001 850 litres; diesel: 11 674 108 litres), translating into a total value of R250 994 136.

RESPONSE: ENERGY EFFICIENCY IN MUNICIPAL FLEET MANAGEMENT

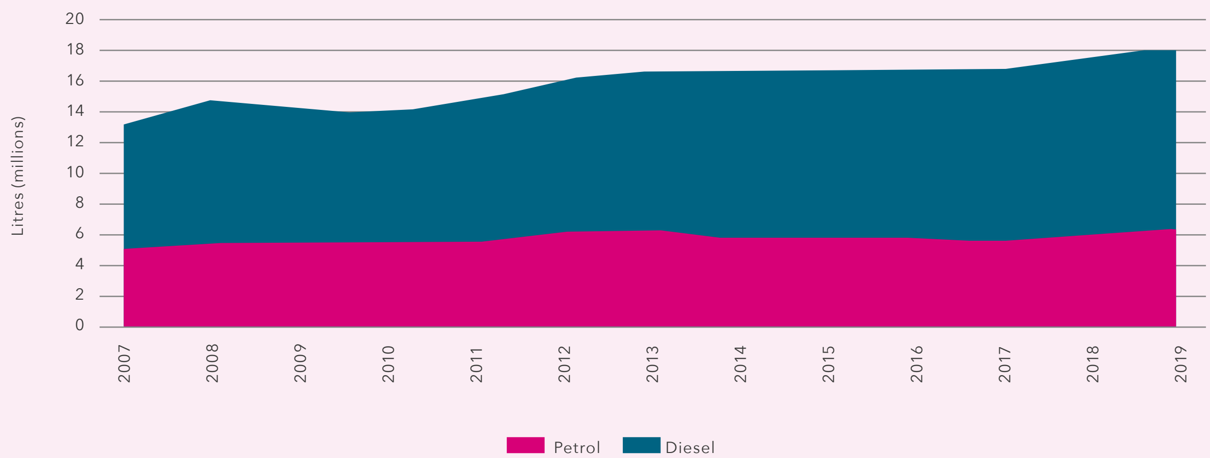
Corporate Fleet Management has established a partnership with the Energy and Climate Change Directorate to determine the extent of environmental compliance in the City's fleet management operations. The aim is to reduce the City's carbon emissions footprint with a view to the Energy2040 goals.

The City is focusing on increasing its green compliance by implementing the following fleet management programmes. Additional programmes for electric and smart transport are discussed under Chapter 5.

- Implemented in 2012, the Smart Driving programme has to date trained and monitored the driving behavioural performance of 4 664 fleet driving staff. The programme aims to achieve and ensure improved road safety and economical driving practices, which would result in lower fuel consumption and carbon emissions, and, ultimately, less operational costs. All drivers who have received this training are monitored via an online automated system, and, to date, fuel consumption has improved by an average of 17%.

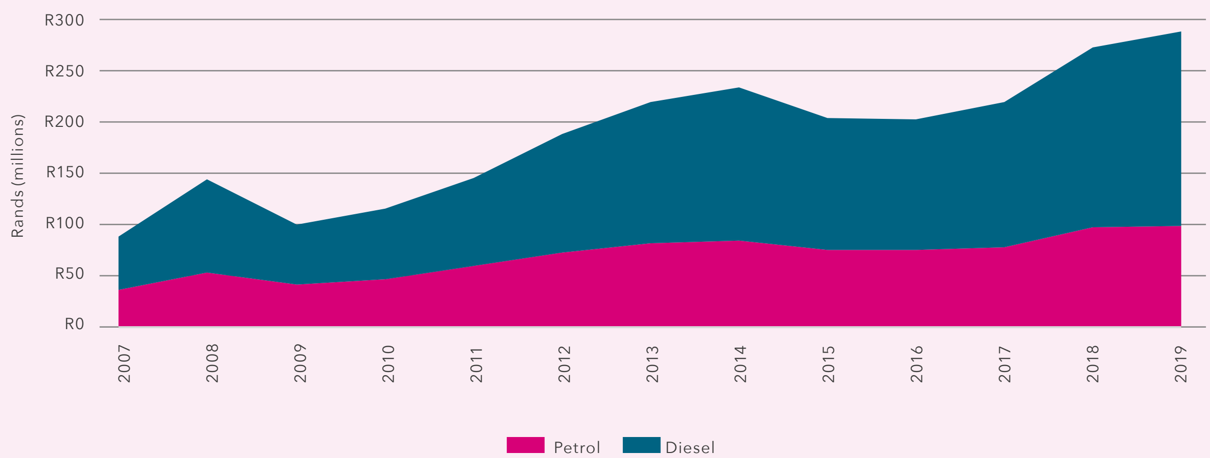
- As part of the Smart Driving programme and an effort to offset the 44 418 tCO_2e emitted from the City's 8 700 vehicles, the municipality actively monitors the tree-planting programme and has an ongoing *Portulacaria Afra* (spekboom) propagation programme, whereby each fleet driver that attends the Smart Driver training, receives a plant to provide awareness of offsetting one's own emissions.
- In December 2019, the City's Law Enforcement Department procured seven e-bicycles at a total cost of R175 000.
- EGD reported a 33% reduction in their fleet's fuel consumption, from 17,1 L/100 km in 2008 to 11,7 L/100 km in 2019. Over the 10 years, this has resulted in a carbon reduction of 30%. The savings are attributed to the rightsizing of the fleet, functionality alignment, 98% attainment of scheduled maintenance, and the monitoring of vehicle speeds.

FIGURE 33: PETROL AND DIESEL CONSUMPTION OF CITY OF CAPE TOWN VEHICLE FLEET IN LITRES, 2007–2019



Source: City of Cape Town, Fleet Management Department.

FIGURE 34: PETROL AND DIESEL CONSUMPTION OF CITY OF CAPE TOWN VEHICLE FLEET IN RANDS, 2007–2019



Source: City of Cape Town, Fleet Management Department.

5.9 RESPONSES – RENEWABLE-ENERGY ROADMAP

5.9.1 CURRENT LOAD-SHEDDING AND ENERGY INSECURITY

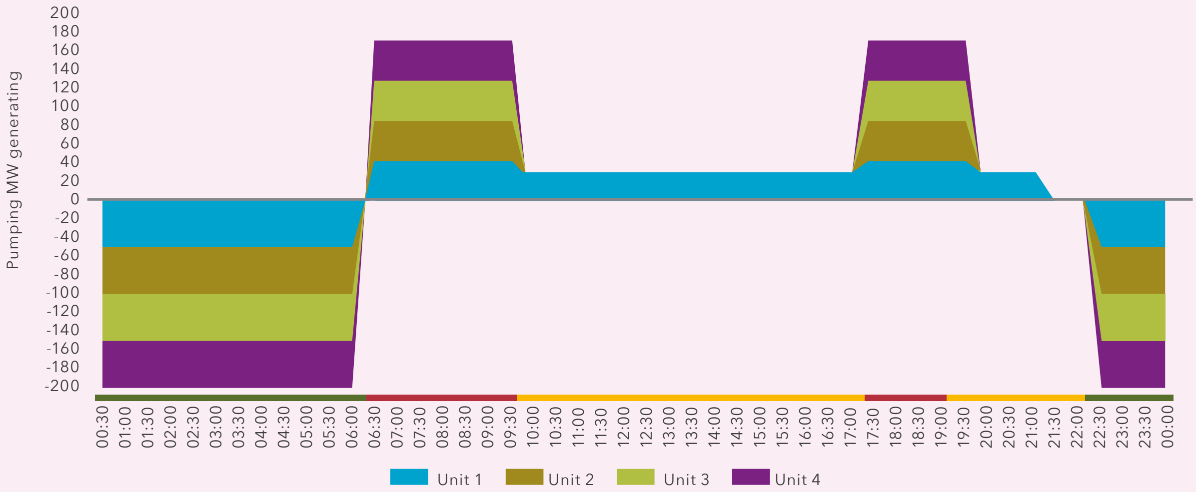
As section 5.4 has shown, the country's current, vertically integrated and highly centralised electricity generation and distribution industry is clearly financially unsustainable. It is also having an enormously negative impact on the country's economy. The power utility of the future will need to change drastically if electricity is to be supplied reliably and cost effectively. The gist of this change will be the move from a one-directional, centralised energy system to a distributed one. Such a system not only allows far more players, including the private sector, but consumers become prosumers and are actively involved in how and from whom they buy electricity. They might even choose to generate electricity themselves and sell it. In preparing to move towards this model, reduce its reliance on Eskom and become less carbon intensive, the City is pursuing and implementing a variety of initiatives.

5.9.2 EXISTING LOAD-SHEDDING MITIGATION OPTIONS

The City is fortunate to own one of the best load-shedding mitigation infrastructures in the country, namely the Steenbras pumped storage facility. In essence, although a net consumer of electricity, the City can shift load away from morning and evening peak times, when the country is in most need of power, and most likely to shed load. Due to Eskom's time-of-use pricing, this also offers the added benefit of saving the City money, which more than offsets any efficiency losses suffered by Steenbras. Steenbras can be operated in a range of ways depending on the objective, which normally is a reduction in maximum demand or energy arbitrage. The operation of the latter is depicted in figure 35 below.

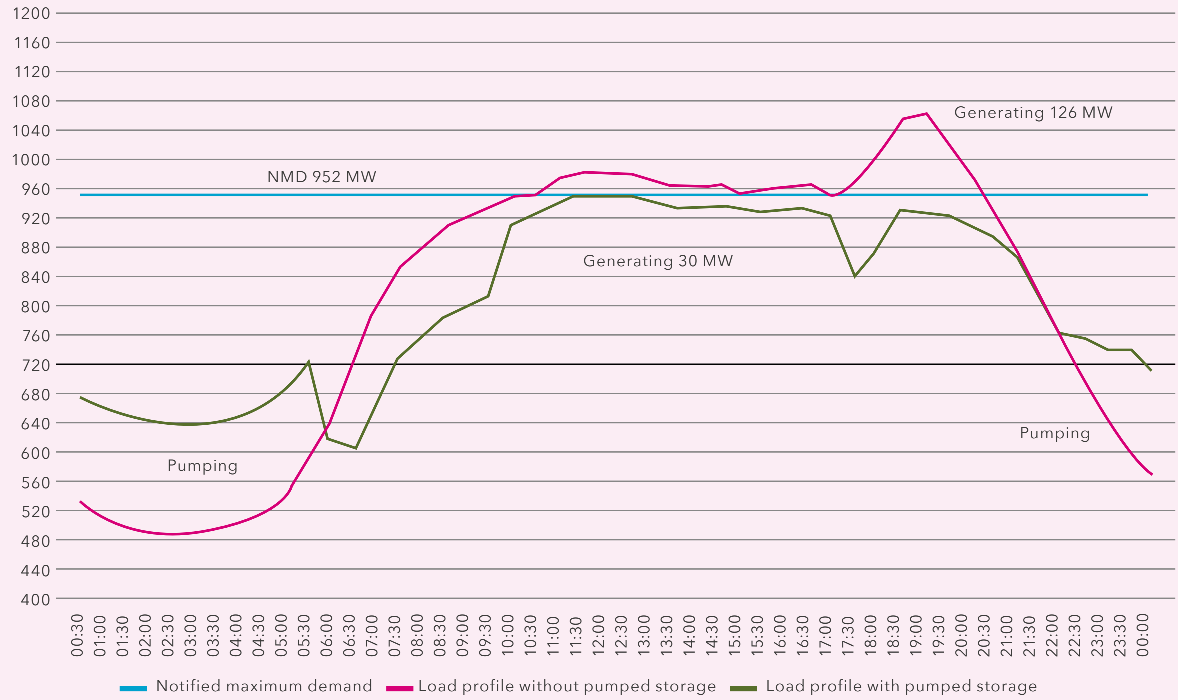
Figure 36 on the next page illustrates how the City's maximum demand can be reduced to avoid incurring penalties from Eskom. This is also similar to how a stage of load-shedding may be avoided: With the dam full, the turbines are utilised to generate the equivalent capacity to what Eskom requires to be shed.

FIGURE 35: ILLUSTRATION OF PUMPING VS GENERATING TIMES OF STEENBRAS ALIGNED WITH TIME-OF-USE TARIFFS



Source: City of Cape Town.

FIGURE 36: ILLUSTRATION OF THE EFFECT OF STEENBRAS IN DECREASING MAXIMUM DEMAND AND SHIFTING/FLATTENING OF PEAKS



Source: City of Cape Town, 2019b.

5.9.3 RENEWABLE-ELECTRICITY ROADMAP

RATIONALE FOR RENEWABLE ELECTRICITY

The downward spiral in Eskom's business, an unstable electricity supply resulting in load-shedding, and the significantly higher-than-inflation price increases of electricity over the past decade, although allegedly as a result of severe mismanagement and corruption, also point to an outdated energy supply business model. In a world where renewable energy can be produced cleanly and brought online quickly, generally by private power producers, a vertically integrated, centralised and coal-based supply utility simply cannot compete. The utility of the future will play much more of an aggregating and grid management role instead of serving a supply, transmission and distribution function. This will allow for more private participants and power producers, as well as provide a platform for energy users also to generate their own electricity, or to decide on the energy source they wish to purchase from.

By 2050, based on the national Integrated Resource Plan (IRP), electricity supplied by the national grid could comprise 70% clean energy, including nuclear (DMRE, 2019). To meet a target of 100% renewable-energy, therefore, the City would have to acquire renewable-energy, particularly electricity, from other sources. The proposed move to 100% renewables for the City by 2050 requires a considerable amount of electricity generation capacity to be established over the next 30 years. The challenge of carbon neutrality and large grids is that if any fossil fuel power is generated onto the grid, no customer will be carbon neutral. Therefore without, complete islanding which will be locally very expensive and also undermine the viability and de-carbonisation of the national system, Cape Town can only approach, not reach, carbon neutrality, even with large investments or purchases from IPPs. Large purchases from IPPs, however, likely mean integration with the national grid in more complex ways rather than islanding. For example if, by 2050, energy demand regains the high of 2009 (approximately 10 000 GWh) and assuming an average capacity factor of 23% for embedded and imported wind and solar power, reaching 80% carbon neutrality would require over 1 650 MW of these technologies to supply Cape Town in addition to a cleaner Eskom.

RENEWABLE-ENERGY ROADMAP AND FUTURE INITIATIVES

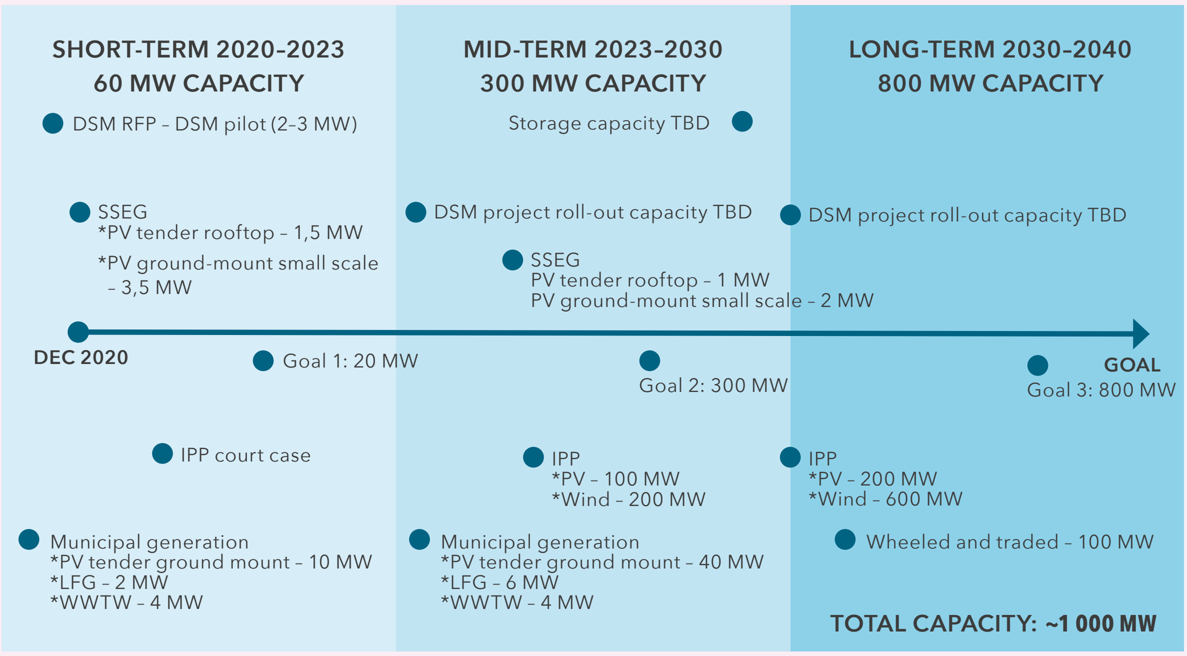
Although it has some modest generation facilities, the City is essentially an 'on-seller' of electricity in a single-buyer model. The City purchases electricity from Eskom at high voltages (66 and 132 kV), and then distributes it to customers through its own distribution network. This already places the City a step ahead of Eskom as a utility, as it is already fulfilling the function of buyer and distributor, as opposed to being a generator as well. Since 2014, the City has also already facilitated the connection of consumer-owned SSEG systems to its grid. (The City's SSEG programme is covered in more detail under section 5.9.)

Moving towards a more carbon-neutral and resilient grid, the City is actively pursuing the following initiatives, which are expanded on in other sections of this report:

- City solar rooftop programme, aiming to install solar PV at its existing facilities
- Development of City-owned utility-scale solar installations on underutilised and undevelopable City-owned land
- Procurement of power from IPPs connected to the City's grid, which will generally be private medium-sized (<10 MWp) solar installations too large to qualify for SSEG
- Procurement of power from IPPs connected to, and wheeling through, Eskom's grid, with the aim of sourcing up to 300 MW of wind and solar power by 2030
- Capturing landfill gas and wastewater biogas to generate electricity, with a total of 6 MWp already under development and planned to come online in 2023

What is clear from the above is that there is a large gap between the renewable-energy capacity increases required to reach the City's renewable-energy targets, and what is considered possible given the current constraints and the pace at which the national electricity landscape appears to be evolving. It is heavily premised on sourcing power from IPPs outside Cape Town's boundaries. To this end, the City is actively engaging with NERSA, Eskom and DMRE through National Treasury's city support programme to expedite the purchase of energy from IPPs.

FIGURE 37: ROADMAP ILLUSTRATING THE CITY OF CAPE TOWN'S POTENTIAL PLAN FOR INCREASED RENEWABLE AND PRIVATE ENERGY SUPPLY



IPs reliant on legistative changes *Non-dispatchable **Dispatchable

Source: City of Cape Town, Sustainable Energy Markets Department.

5.10 RESPONSES – CITYWIDE SMALL-SCALE EMBEDDED GENERATION

5.10.1 SOLAR PHOTOVOLTAIC POWER

Along with decarbonisation, decentralisation of energy generation is a major global trend. Technological advancements and improved economics are allowing customers to have greater control of their energy needs, and a new market segment of 'prosumers' is emerging.

Solar PV is the key technology enabling the transition to a sustainable energy system at distribution network level. Rapid investment cost reductions of 60–80% since 2010 have increased the economic appeal of solar PV, facilitating the adoption of residential, commercial and industrial applications. This downward cost trend was also reflected in DMRE's REIPPPP, where the average tariff for solar PV dropped from R3,65/kWh in bid window 1 to R0,91/kWh in bid window 4. By contrast, the cost of energy from large, centralised fossil fuel generators is steadily increasing. In addition, South Africa's national power crisis and associated load-shedding have provided further impetus for electricity consumers to explore alternative energy options.

In 2018, distributed solar PV additions reached a record 41 GW globally, accounting for more than 40% of total PV and a quarter of all renewable capacity growth. With this expansion, global distributed PV (led by commercial and industrial applications) reached 213 GW.

REGULATORY FRAMEWORK FOR SMALL-SCALE EMBEDDED GENERATION (SSEG)

SSEG is currently not regulated at the national level, although the DMRE and NERSA are making progress in developing overarching regulatory rules. In the absence of a national regulatory framework, the City has developed its own rules for the registration and authorisation of SSEG in its electricity supply area.

5.10.2 SMALL-SCALE EMBEDDED GENERATION IN CAPE TOWN

The City introduced its first SSEG tariff in July 2012, adding a feed-in tariff the following year. With rapid SSEG growth and no national legislative framework governing it, the City responded by developing a by-law that required SSEG systems to be registered, and grid-tied installations to comply with defined standards. Non-compliant systems create safety risks and legal challenges for network operators, infrastructure, homeowners and the City itself.

Yet illegal systems remain an ongoing challenge. An awareness campaign was launched in July 2018 to educate customers about the need to register their SSEG systems, and the implications of unauthorised systems. The registration process was communicated to citizens through social media, rates bill inserts and an online video. The City also extended its original registration deadline and created an online preregistration portal to make it easy for residents to initiate the process. The registration campaign proved very successful, tripling the number of applications.

The climate change mitigation role of SSEG was recognised in the City's 2015 Energy2040 climate change mitigation goal, which targeted 120 MW of citywide rooftop solar PV SSEG by 2020. While the market did not quite reach this ambitious aspirational target, growth has been exponential. By the end of 2020, approved, installed and commissioned grid-tied residential and commercial system capacity had exceeded by 45 MW. Applications for a further 41 MW were in process or had received permission for installation, including 3 MW off-grid, bringing the likely near-term capacity to around 86 MW.

SSEG REQUIREMENTS

The City's Electricity Supply By-law requires anyone wanting to connect a generator to the City's electricity network to obtain consent from the EGD director. To this end, the City has developed a comprehensive document entitled "Requirements for small-scale embedded generation", which details the application and authorisation process for connecting SSEG systems to the City's electricity network. The requirements in the document apply to all SSEG systems with a generation capacity of up to 1 MVA.

GROWTH IN SMALL-SCALE EMBEDDED GENERATION IN CAPE TOWN

In line with global trends, Cape Town has seen a significant increase in the uptake of SSEG. The figures below depict the growth of grid-tied SSEG that have been approved by the City. By December 2020, the total number of approved grid-tied SSEG installations was 1 264 with a total capacity of 47,63 MVA.

Rooftop solar PV is the preferred technology choice, mainly due to its favourable economics and easy installation and operation. By December 2020, over 99% of grid-tied SSEG installations were PV systems, with the remainder being wind. Consequently, over 99% of installed capacity was also from rooftop solar PV. The residential sector accounts for 68% of installations, but only 10% of total capacity, while the commercial and industrial sector accounts for 32% of installations and 90% of total capacity.

RESIDENTIAL SECTOR

By December 2020, a total of 2 261 applications for grid-tied residential SSEG installations (in various stages of approval) with a capacity of 13,1 MVA had been received. Altogether 985 approved grid-tied residential SSEG installations had been commissioned with a capacity of 5,71 MVA, and 687 approved off-grid residential installations with a total capacity of 3,1 MVA.

COMMERCIAL AND INDUSTRIAL

Altogether 519 applications for grid-tied commercial and industrial SSEG installations (in various stages of approval) with a capacity of 74,1 MVA had been received by December 2020. A total of 279 approved grid-tied commercial and industrial SSEG installations had been commissioned with a capacity of 41,9 MVA, and 16 approved off-grid commercial and industrial installations with a total capacity of 0,13 MVA.

FIGURE 38: APPROVED GRID-TIED, COMMISSIONED SMALL-SCALE EMBEDDED GENERATION – INSTALLATIONS

Source: City of Cape Town, Electricity Generation and Distribution Department.

FIGURE 39: APPROVED GRID-TIED, COMMISSIONED SMALL-SCALE EMBEDDED GENERATION – CAPACITY

Source: City of Cape Town, Electricity Generation and Distribution Department.

5.11 RESPONSES – UTILITY-SCALE RENEWABLE-ENERGY

In addition to enabling the integration of SSEG safely and cost reflectively into the network, the City is pursuing larger scale projects and programmes to further reduce the local system's reliance on Eskom as sole generator. While Eskom, particularly its transmission and system operation functions, remains a key partner, these are steps towards a cleaner, more affordable and more reliable city electricity supply.

5.11.1 CITY OF CAPE TOWN GRID-CONNECTED INDEPENDENT POWER PRODUCERS

This programme aims to procure power from private generators, who will connect directly to the City's existing distribution grid, generally at an existing medium-voltage substation. Although the project sizes will vary, and be determined as the programme develops and market participation increases, they are likely to be too large to qualify as an SSEG (<1 MVA), but significantly smaller than the limits for national REIPPPP projects (>25 MVA). Projects are anticipated to be in the range of 2–10 MVA each. It is hoped that private generators will supply approximately 100 MWp through this programme in the next 10 years.

5.11.2 ESKOM GRID-CONNECTED INDEPENDENT POWER PRODUCERS

This programme will aim to leverage both Eskom's transmission network and the significantly better solar and wind resources outside the City's network by providing the private developers of these large facilities an alternative to Eskom as the current single buyer of their power. Although involving additional parties (Eskom) and longer lead times, the programme should be technically simpler to implement from the City's perspective, as the required infrastructure (the primary Eskom intake points) is already in place. It is hoped that 300 MVA of power will be supplied to the City through this programme by 2030.

5.11.3 STORAGE

Critical to developing the grid of the future, which will include large amounts of variable renewable-energy, is the inclusion of substantial storage capacity. This capacity can take the form of grid-scale electric batteries, pumped storage, or innovative new technologies, such as gravity or compressed air storage. The City is actively pursuing these options through the assessment of proposals by private companies, as well as by the development of a battery-stacking tool to better quantify the benefits of storage addition to the grid. Grid storage not only helps provide reliable electricity even when the sun is not shining or the wind is not blowing, but can also defer grid investment costs by reducing maximum demand on portions of the grid. Moreover, traditional electric batteries have the added benefit of being able to provide ancillary services, such as frequency control, which improve grid reliability.

5.11.4 OWN GENERATION – BULK SUPPLY

The City has identified several tracts of land that are underutilised, or cannot be economically developed. These are being actively developed for the purpose of solar power generation. At the time of writing, the outcome of final specialist studies was being awaited, and the aim was hopefully to break ground by the end of 2021. The table below indicates the potential locations and sizes of these developments.

At the same time, though, these developments and their details are extremely fluid and subject to change as studies and assessments progress. In a year's time, they may look very different from what is presented above. This, therefore, is merely a best estimate based on current data.

Other City departments outside Electricity, particularly Solid Waste and Wastewater, are also developing their own generation projects. (See section 7.3 for further details.) SEM is assisting them with their applications for NERSA licences.

TABLE 8: PLANNED CITY-OWNED SOLAR PHOTOVOLTAIC DEVELOPMENTS

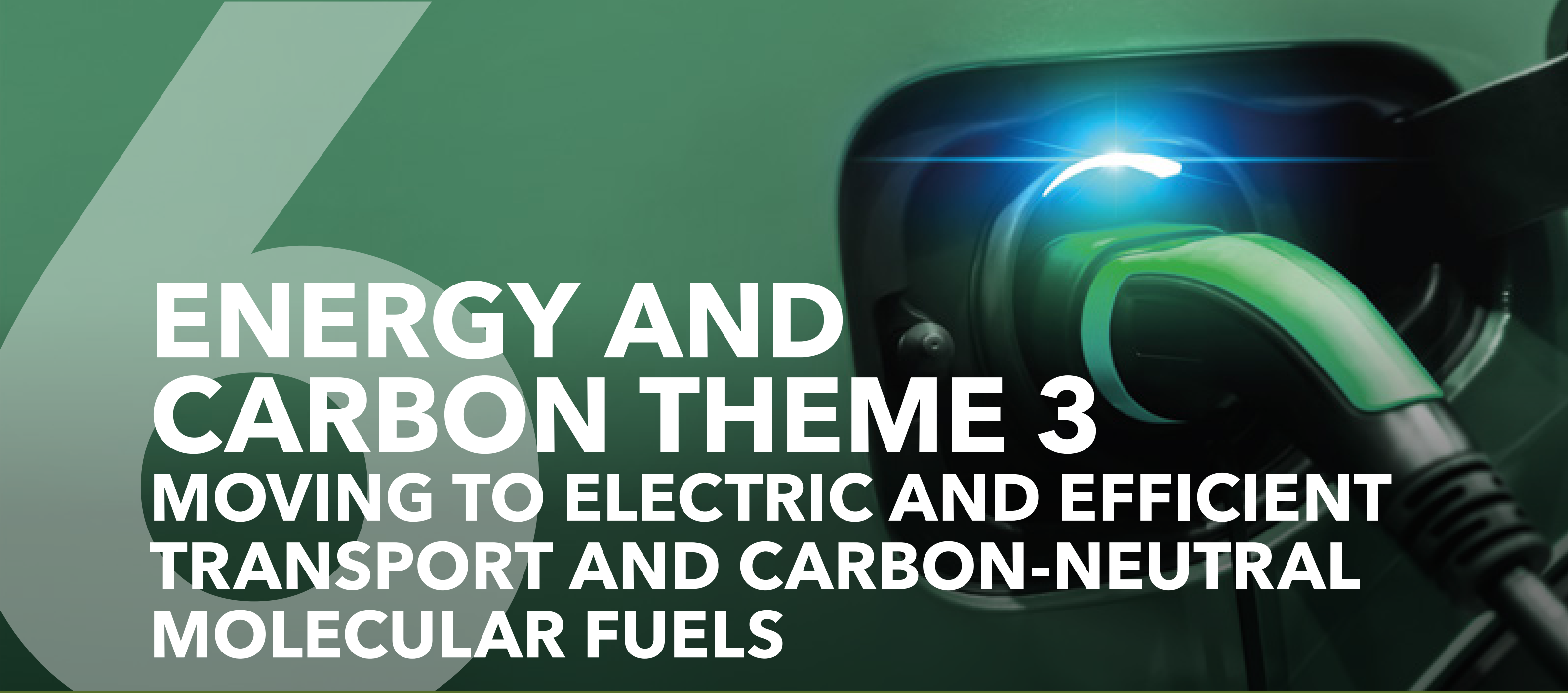
Area	Potential size	Planned start of construction
Atlantis	10 MWp	2022
Athlone	1,5 to 2 MWp	2024
Somerset West (Paardevlei)	20 to 60 MWp	2024

Source: City of Cape Town.

TABLE 9: SELF-GENERATION PROJECTS OUTSIDE THE ELECTRICITY DEPARTMENT

Department	Technology	Total capacity
Wastewater	Biogas	10 MW
Solid Waste	Landfill gas	7 MW

Source: City of Cape Town.



ENERGY AND CARBON THEME 3

MOVING TO ELECTRIC AND EFFICIENT TRANSPORT AND CARBON-NEUTRAL MOLECULAR FUELS

6.1 CONTEXT AND CHALLENGES – ENERGY SECURITY, EXPANDING IMPORTS AND THE ECONOMICS OF REFINERIES

Due to South Africa's lack of crude oil reserves, almost 100% of the country's crude oil requirements are met through imports, rendering the nation vulnerable and highly dependent. This is exacerbated by the fact that four of the six refineries in the country are crude oil-based and account for over 70% of South Africa's refining capacity. The Astron refinery, which is located within Cape Town's boundaries, is one such refinery.

Not all refineries are the same. Each refinery is a unique and complex industrial facility with some flexibility in the crude oils it can process and the mixture of products it can refine. Each refinery constantly weighs a number of factors, including the type and amount of crude oil to process, and the conditions under which various conversion units operate. However, there are certain limits as to how flexible a refinery can be. The configuration and complexity of each facility determines the types of crude oil it can process and the products it can produce. Location and transportation infrastructure further limit the degree to which the refinery can access various types of crude and other supplies. These factors, in turn, affect energy and labour costs, as well as regulatory constraints and compliance costs.

Determining the profitability of a specific refinery is very difficult, since data on operational and environmental compliance costs are generally not available. A rough measure could be obtained by calculating the cost of the crude oil feedstock, and comparing that cost with the market value of the suite of products produced at the refinery. Accurately determining the costs of the crude oil feedstock would require knowledge of crude blends used in the specific refinery, which information may not be publicly available.

A useful but simplified measure of refinery profitability is the 'crack spread'. The crack spread is the difference between the sales price of the refined product, and the cost of crude oil. An average refinery would follow what is known as the 3-2-1 crack spread: For every three barrels of oil, the refinery produces an equivalent two barrels of petrol and one barrel of distillate fuels (diesel and heating oil). The crack spread is only a first-order approximation of how profitable a refinery would be at the margin. The higher the crack spread, the more money the refinery makes, so it will utilise as much capacity it has available. Alternatively, at a lower crack spread, it may be in the refinery's best interest to scale back on the amount of capacity utilised due to lower profits (Penn State – Department of Energy and Mineral Engineering, n.d.).

As indicated, the crack spread is not a perfect measure of refinery profitability, but only an approximation. In reality, refineries must consider their refining costs in addition to just the cost of crude oil. These costs include labour, chemical catalysts, utilities, and any other short-term costs needed to maintain refinery operations. These variable costs will affect the crack spread negatively, resulting in a much lower margin for the refinery.

The crack spread tends to be sensitive to the slate of products produced from the refinery. Refineries may be engineered to maximise production of petrol or diesel. The crack spread is also sensitive to the crude oil input. There are more than 150 types of crude oil in the world, and the basic choice of which crude to refine is between lighter and heavier grades. Heavier crude oils are cheaper and increasingly plentiful, but are more expensive to refine. Lighter grades require less upgrading at the refinery, but are in decreasing supply. Lighter oils tend to have a lower sulphur content, which makes them 'sweeter', as opposed to 'sour' oils with a higher sulphur content. Crude oil is mainly traded on futures contracts due to the volatility of crude oil prices. The most popular grade of crude oil traded is light, sweet crude oil, along with Brent blend, which is the benchmark by which petrol prices are determined (Canadian Fuels Association, 2013).

6.2 CONTEXT AND CHALLENGES – REFINING, THE LIQUID FUELS IMPORTS TERMINAL, AND MARINE AND INDUSTRIAL FUELS

Cape Town is home to the Astron refinery, a key strategic asset that supplies the western region of the country with liquid fuels. The refinery has a production capacity of 100 000 barrels a day – 14% of the national capacity of 718 000 barrels a day (SAPIA, 2018). Astron is connected with Cape Town harbour via a 12" white-product[15] pipeline, which facilitates both the import and export of refinery products. A 26" crude pipeline and a 10" heavy fuel oil pipeline also run between the refinery and the harbour (Transnet, 2017). The Astron refinery is currently licensed to import roughly 12 million barrels per year (33 000 barrels per day) of white product via Cape Town harbour, and can store the oil either at its refinery or at third-party storage facilities. It is also connected to the large-scale strategic crude storage facilities in Saldanha Bay. The refinery currently produces petrol, diesel, jet fuel, LPG, fuel oil and certain chemicals for industrial use. Astron is not yet compliant with Euro V fuel standards.

Burgan Cape Terminals is a new storage and distribution facility with a capacity of approximately 120 000 m^3 (750 000 barrels) located in the port of Cape Town. Operation of the facility began in 2017 after Transnet National Ports Authority awarded Burgan a 25-year lease to develop a new, independent fuel storage, distribution and loading facility. The terminal is part-owned by international firm VTTI/Vitol and B-BBEE companies Thebe Energy and Jicarro. The facility includes storage for diesel, petrol, fatty-acid methyl esters, ethanol and jet fuel. Notably, this terminal can facilitate the import of Euro V fuels from mega-refineries internationally. Based on the existing truck loading infrastructure and associated constraints, it is estimated that Burgan Cape Terminals currently has a throughput capacity of about 1 030 000 m^3 per annum (18 000 barrels per day). Roughly 75% of the storage and throughput capacity is reserved for diesel (Burgan Cape Terminal, n.d.) (EScience, SEA and CAPIC, 2019).

The other storage facilities at the port are BP Montague Gardens and Engen Montague Gardens. The BP Montague Gardens storage facility is licensed to store approximately 80 000 m^3 (500 000 barrels) of white product, while the Engen Montague Gardens facility can reportedly store about 60 000 m^3 (380 000 barrels).

The Astron refinery is a supplier of heavy fuel oils, which are used as marine fuels and as industrial heating fuels. However, the South African marine bunker market has seen sharp declines in recent years. Durban moves only approximately one million tonnes of bunker fuel per annum, while Cape Town has also seen reduced bunker volumes. Competition has largely been from Mauritius as a result of its strategic location in the Indian Ocean. Significant liberalisation of the Mauritian bunker market took place in 2014, when the Mauritian government provided incentives such as the reduction and removal of charges and duties, and an improved process for issuing of licences and import permits. The marine bunkering sector has also seen more stringent environmental requirements in recent years. In January 2020, the International Maritime Organisation (IMO) introduced a new regulation for a 0,05% global sulphur cap for maritime fuels to reduce the amount of sulphur oxide. The Astron refinery has subsequently been upgraded to supply IMO 2020-compliant bunker fuel to the ports of Cape Town and Richards Bay.

15 Refined, value-added petroleum products.

6.3 CONTEXT AND CHALLENGES – INDUSTRY AND HEATING FUELS (AND COAL TRADERS)

The industrial sector can be divided into three distinct industry types: energy-intensive manufacturing, non-energy-intensive manufacturing, and non-manufacturing. The mix and intensity of fuels consumed in the industrial sector vary across regions and countries, depending on the level and mix of economic activity, and on technology development. Energy is used in the industrial sector for a wide range of purposes such as process and assembly, steam and cogeneration, process heating and cooling, lighting, heating, and air conditioning. Industrial-sector energy consumption also includes basic chemical feedstock.

Industrial energy requirements are met from many different energy sources. These include natural gas, petroleum (residual fuel oils, hydrocarbon gas liquids, distillate fuel oils), electricity and renewable-energy sources (biomass). According to the national 2017 energy balance, the industrial sector is responsible for 47% of end-use energy consumption in South Africa, comprising electricity (29%), coal (23%), gas (12%), renewable energy and waste (30%), and petroleum products (7%). The industrial energy landscape for Cape Town is very different from the national picture, however. In 2018, manufacturing and construction constituted 6,8% of the total end-use energy consumption (including marine and aviation) (figure 2) in the city, comprising electricity (55%), diesel (22%), coal (12%), paraffin (6%), LPG (3%), heavy fuel oil (2%) and biomass (1%). Key industrial applications in Cape Town utilising these fuels include steam raising, baking, drying, heating and smelting.

Paraffin is used extensively in wick feed and pressure lamps, stoves, refrigerators and heaters. It is also used as a solvent in the manufacture of certain paints, varnish, polish, insecticides and weed killers. In addition, industrial use of paraffin includes process air heating, heating of liquids in tanks, and firing of gas turbines.

Heavy furnace oil, also sometimes called residual oil, is used in high-volume industrial heat fuel applications such as steam and hot-water boilers, furnaces and kilns, as well as very large drying operations. Major applications are found in the cement, ceramic and glass industry, metal and ore smelting, and the asphalt industry. Residual oils are an alternative to coal, depending on the oil price. The local facilities of FFS Refiners recover residual and used oils, including lubricating oils, to produce industrial heating and marine bunker fuels.

Apart from road transport, diesel finds extensive application in off-road vehicles, and machinery used to remove and transport materials such as ore, soil and finished products. By design, diesel is not readily flammable in its liquid form at ambient conditions, and, therefore, is also a useful burner fuel for heating.

LPG is used across the heating spectrum, satisfying all industrial requirements for space heating, heating of liquids in tanks, inert gas generation, and hot-water boilers and furnaces. LPG is also used for drying operations in the paint, paper, food and glass industries, as well as for incineration and metal cutting.

Given Cape Town's location, coal carries a transport premium, but is cheap enough to find a local market for industrial heating, particularly in the industries of brickmaking and ceramics, textiles, processed food and beverages, chemicals and pharmaceuticals, ferrous and non-ferrous metals, and packaging. Coal supply to Cape Town is undertaken by a number of traders, some quite small. This, along with the diverse uses and industries on the demand side, make statistical assessment difficult, and estimated consumption can only be deduced from sporadic surveys and air quality management licensing data, which are, at best, indicative.

6.4 CONTEXT AND CHALLENGES – OVERVIEW OF TRANSPORT DEMAND, CONGESTION, TRAVEL TIMES, COSTS AND PUBLIC TRANSPORT

The City is committed to making Cape Town a place where travel is safe, reliable and economically viable; where public transport (including minibus taxis) is preferred to private vehicles; where a formal transport system is complemented by appealing active mobility, and where walking is safe and cycling infrastructure is a depoliticised, efficient and healthy utility.

The current spatial form of Cape Town negatively affects many residents, forcing many – particularly those who can least afford it – to travel long distances to reach workplaces, schools and services such as healthcare. Cape Town has a historical endowment of electric rail infrastructure, which has been the backbone of transport in the city and remains the cornerstone for transport planning. However, the service, which is operated by Metrorail, a division of the state entity PRASA (Passenger Rail Agency of South Africa), is in abject crisis, offering a stark warning that ambitious plans require a society where all stakeholders collaborate to make things work for the common good.

Over time, population growth and property development in outlying areas of the city have made heavier demands on commuter services, and private vehicles have historically increased at nearly 3% per annum.[16] However, transport demand has also been thrown into disarray as a result of the Covid pandemic, which may ultimately result in a step change in mobility trends. Transport planners are still grappling with how the new normal might affect different income groups and geographical areas: While economic activity has generally been supressed, some groups and areas have experienced sustained travel demand, while others have seen travel demand reduce due to flexible work hours and work-from-home trends. Vehicles transporting freight over long distances between Cape Town and other centres nationwide continue to be a substantial source of transport fuel demand, although e-commerce is also disrupting the traditional ways in which goods are transported around town.

In Cape Town, the transport sector (including marine and aviation) accounted for an estimated energy share of 67% in 2018. Fossil fuels used by internal combustion engines are the second biggest source of the city's emissions (after electricity consumption). Fossil fuels are also a net drain on the economy, exposing it to volatile crude oil prices.[17] Traffic congestion and inefficiencies have been on the rise, leading not only to an increase in Cape Town's GHG emissions, but also to poor air quality and associated health impacts on our residents.

To reduce energy demand and emissions from the transport sector, the City will need to continue building an efficient and, ultimately, electric transport network through the best-practice EASIA (enable, avoid, shift, improve, adapt) framework (World Bank, 2015). This entails promoting efficiencies in transport governance, land use, multimodal transportation, road space usage, and vehicles. In the local context, EASIA involves enabling a shift to walking and cycling, while switching to electric vehicles off the back of clean energy, continuing the longstanding national and local efforts to achieve better public transport, and, in particular, being proactive in terms of the rail system so that its future role in the system is clear. Meanwhile, the City needs to be proactive about ensuring that it capitalises on the global trend towards electric vehicles and their manufacture, while decarbonising the local electricity supply.

16 National Traffic Information System (eNatis) 2012–2017.
17 From 2002 to 2014, petrol nearly doubled in real-term costs, and then dropped by close to half that rise by 2017.

6.4.1 LEGISLATIVE CONTEXT

The National Land Transport Act of 2009 defines the responsibilities of the three spheres of government with regard to transport. The responsibilities of the municipal sphere are particularly extensive, with 28 separate directives covering policy, technical and financial planning, information systems, safety, service provider contracts, concessionary fares, roads, and even marketing and promoting public transport. Key to the energy and carbon implications of transport are the following municipal responsibilities (Department of Transport, 2009):

- Developing land transport policy and strategy within the municipal area based on national and provincial guidelines, which includes its vision for the area and incorporates spatial development policies on matters such as densification and infilling, as well as development corridors
- Ensuring coordination between departments and agencies in the municipal sphere with responsibilities that affect transport and land-use planning issues, and bringing together the relevant officials
- In the municipality's capacity as planning authority, preparing transport plans for its area, ensuring the implementation thereof, and monitoring its performance in achieving its goals and objectives
- Encouraging and promoting the optimal use of the available travel modes so as to enhance the effectiveness of the transport system and reduce travelling time and costs
- Developing, implementing and monitoring a strategy to prevent, minimise or reduce any adverse impacts of the land transport system on the environment in the municipal area
- Developing, operating and maintaining a land transport information system for the municipal area
- Planning, implementing and managing modally integrated public transport networks and travel corridors for transport within the municipal area, and liaising in that regard with neighbouring municipalities
- In relation to the planning functions, conduct service-level planning for passenger rail on a corridor network basis, in consultation with the South African Rail Commuter Corporation

These responsibilities have been supported by substantial national grants since 2010. The Public Transport Network Grant (PTNG) funds the infrastructure and operations of integrated public transport networks in 13 cities across South Africa, including Cape Town. The objective of the PTNG is as follows (Department of Transport, 2018):

"To provide funding for accelerated construction and improvement of public and non-motorised transport infrastructure that form part of a municipal integrated public transport network, and to support the planning, regulation, control, management and operations of fiscally and financially sustainable municipal public transport network services."

Therefore, the grant has a planning and construction component, and also funds the indirect operating costs of Integrated Public Transport Networks (IPTN) in those cities that have operating systems. In Cape Town's case, this is the MyCiTi scheduled bus service. The support of the PTNG, and the magnitude of the task of expanding a high-quality scheduled bus service across transit corridors, were reflected in a capital expenditure budget vote of almost R1,8 billion for transport in 2020/21, second only to water and waste. This allocation is expected to increase further in the 2021/22 and 2022/23 financial years, reaching R2,3 billion as the Phase 2A MyCiTi expansion (see section 6.6) gets under way (City of Cape Town, 2020d). The pace at which this can happen, therefore, is contingent on the PTNG grant being available as planned.

6.4.2 ROAD-BASED PRIVATE TRANSPORT

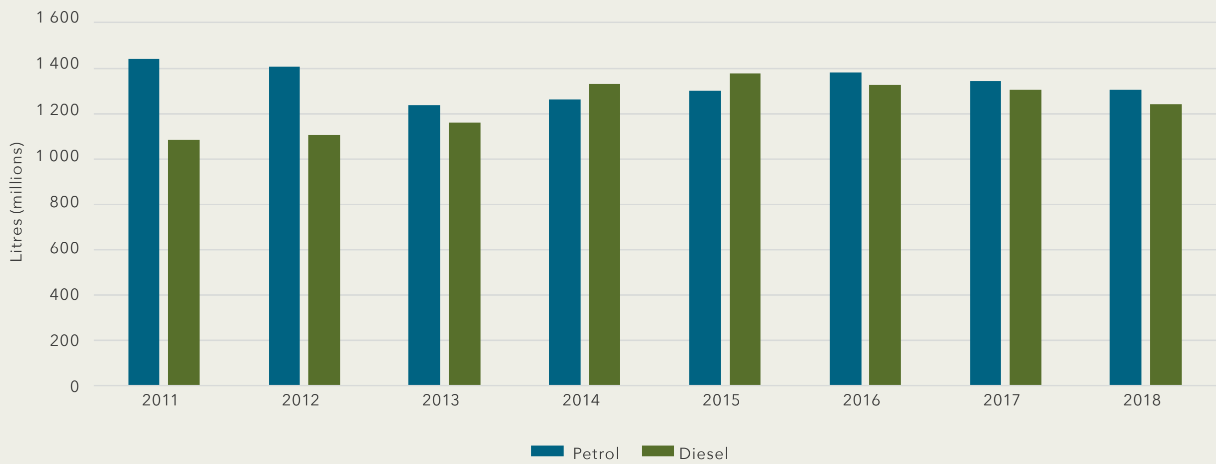
Corresponding with increasing emissions from the transport sector, there has been a steady increase in all classes of vehicles on Cape Town's roads (see annexure 10.6, table A34). Minibus taxi numbers were relatively static prior to the collapse of PRASA's railway service, implying slowly diminishing mode share, yet grew by an astonishing 30% between 2013 and 2017. Prior to this, rail accounted for the highest number of passenger trips in Cape Town. The rail crisis has resulted in a surge in road usage, dramatically worsening congestion moving to the city centre (Transport and Urban Development Authority, 2016). Minibus taxis are now the City's largest public transport provider (EScience, SEA and CAPIC, 2019).

6.4.3 TRANSPORT SECTOR ENERGY OVERVIEW

Transport is the largest energy-consuming sector in Cape Town, which is largely attributed to the liquid fuels used by road-based vehicles (figure 40). Over the period 2011–2018, petrol has seen a compound annual growth rate of -1,41%, while diesel grew by 1,96%. Although the number of vehicles has increased, the petrol sales data indicate a general decrease. This can be attributed to increasing vehicle efficiencies, as well as the general trend of consumers downsizing their vehicles. In addition, with the increase in the minibus taxi population, Sustainable Energy Africa (2019) has found that fuel consumption of these taxis is approximately five times more efficient than other passenger vehicles.

Diesel consumption appears to have increased over time. This may be due to an increase in the use of generators by both industry and households during load-shedding, as well as consumption by both on and off-road vehicles.

FIGURE 40: PETROL AND DIESEL CONSUMED IN CAPE TOWN



Source: Department of Mineral Resources and Energy (DMRE).

6.4.4 TRANSPORT MODAL SPLIT

The increase in private vehicles is a concern in many metros around the world (Zhang, Liu, Qin, and Tan, 2020). Over the past 10 years, Cape Town's modal split has been dominated by the growth in the number of private vehicles (eNatis, 2018). The National Department of Transport's goal is a 20:80 modal split between private and public transport to alleviate congestion and reduce air pollution countrywide. Furthermore, the City seeks to provide an efficient, high-quality public transport system to enable residents to live car-independent lifestyles (if they choose to). Therefore, the City wants to track the shift in modal share over time (City of Cape Town, 2019a). The citywide modal split for trips to work in the morning peak period in 2018 is shown in table 10.

TABLE 10: CITYWIDE MODAL SPLIT TO WORK IN MORNING PEAK PERIOD, 2018

Private transport	Rail	Minibus taxi	Bus	Bus rapid transit (MyCiTi)	Non-motorised transport
51%	13%	21%	11%	2%	2%
51%	**47%**				**2%**
	28%	46%	23%	4%	

Source: City of Cape Town, 2019a.

Figure 41 illustrates the increasing trend of private vehicle ownership, which results in an increase in congestion and air pollution. In 2011, the majority of households did not own a vehicle; by 2018, however, that trend had been reversed. This is clear from the eNatis data, which show that light passenger vehicles on the road increased by approximately 150 000 from 2011 to 2018.

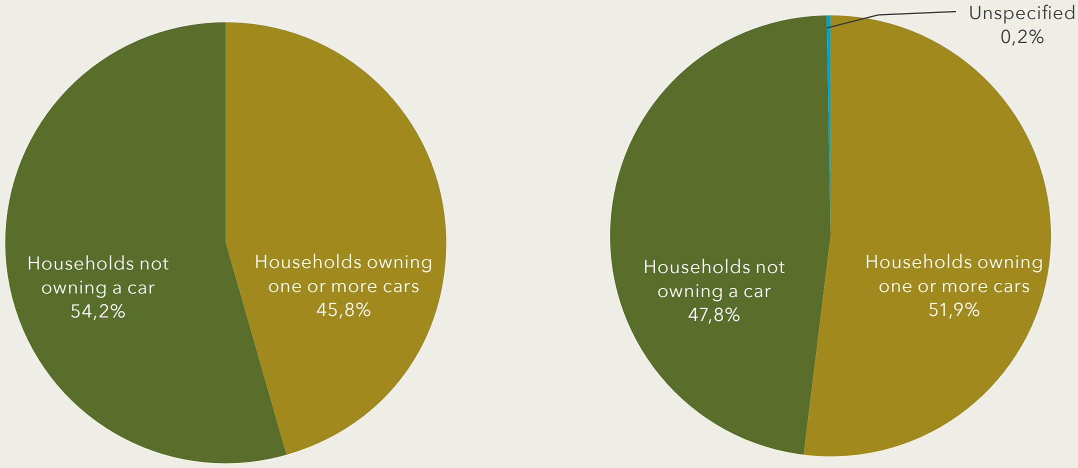
While the rising popularity of private vehicles is the result of a number of factors, one key contributor is the mismanagement of the railway system, which historically accounted for the highest volume of public transport trips into Cape Town (Transport and Urban Development Authority, 2016).

The City's Urban Development Index (UDI) reports, among other indicators, the extent of congestion in Cape Town and measures:

- total congestion length of the network (citywide per road class in kilometre), which is reported as the maximum length and that only occurs for a short time interval;
- duration of peak period in the morning and afternoon (citywide per road class in hours); and
- total congested network hours (km-hours of congested network) citywide per road class.

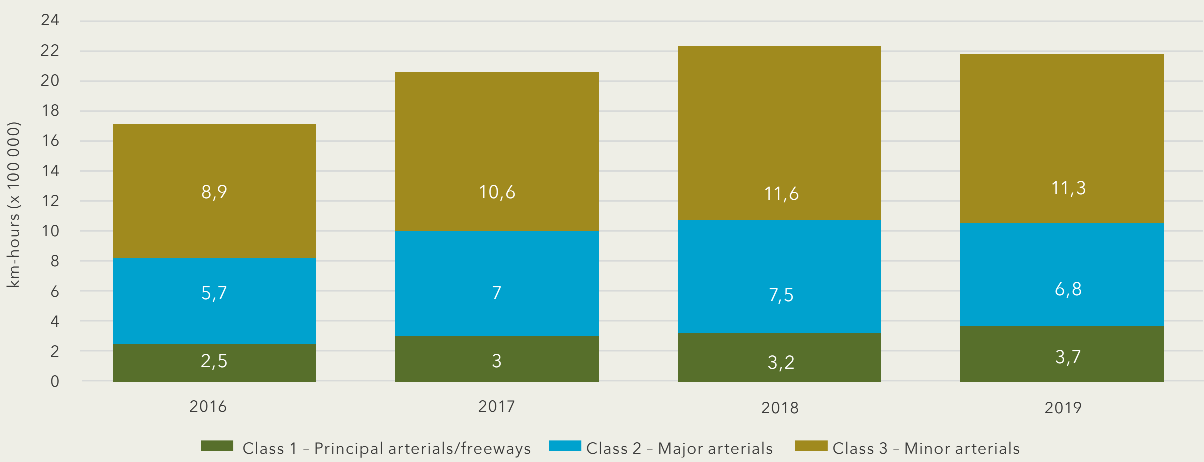
The extent of congestion on Cape Town's high-order roads (principal [class 1], major [class 2] and minor [class 3] arterials) is shown in figure 42. The total number of congested network hours for 2019 was close to 2,2 million km-hours, slightly down from 2018, when it exceeded 2,2 million km-hours.

FIGURE 41: OWNERSHIP OF A MOTOR VEHICLE IN CAPE TOWN, 2011 (LEFT) AND 2018 (RIGHT)



Source: Stats SA General Household Survey.

FIGURE 42: EXTENT OF CONGESTION ON CAPE TOWN'S HIGH-ORDER ROADS (2016–2019)



Source: City of Cape Town, 2019a.

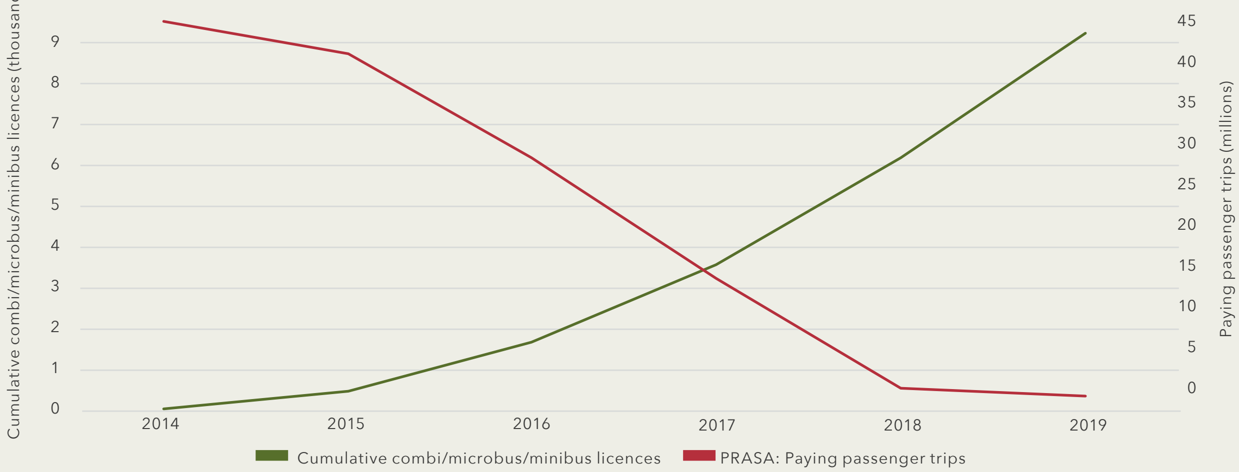
6.4.5 PUBLIC TRANSPORT

The City has done significant work to promote public transport. (High-level statistics for public transport fleets are presented in annexure 10.6, table A38.) From 2012 to 2018, the MyCiTi bus network increased its peak fleet by 267%, and the number of routes operated from seven to 40 (City of Cape Town, 2020e).

Income and public transport are strongly correlated in Cape Town. Typically, use of public transport is high among low-income residents and minimal among high-income households. Private transport is the preferred mode once the financial means are available. The recent drop in the availability and quality of public transport alternatives, especially in terms of rail, has added a new dimension to this picture. Rail capacity declined by around 75% between 2014 and 2018 (figure 43), and the Central Line service was eventually completely discontinued. Land invasions during the Covid lockdown have since rendered parts of the Central Line unusable, and restoring the service poses financial, legal, security and technical challenges. After a period of slow decline, the minibus taxi industry too has grown in response to the crisis in the rail system, with the number of licensed minibus taxis now estimated to be well above 10 000 in Cape Town (eNatis, 2018; Western Cape Department of Transport, 2018).

An integral part of the City's spatial strategies is to reduce accessibility costs for the poor in the long term. Shorter travel times and a shift to more cost-efficient modes, such as public and non-motorised transport, are expected to translate into lower direct cost expenditure on transport. The monthly transport expenditure for commuters based on typical work trips in 2018 is shown in table 11 (City of Cape Town, 2019a).

FIGURE 43: EXPANSION OF THE LICENSED MINIBUS TAXI FLEET IN RESPONSE TO THE FAILURE OF THE METRORAIL STATE UTILITY RAIL SERVICE IN CAPE TOWN



Sources: eNatis, 2018; Western Cape Department of Transport, 2018.

TABLE 11: DIRECT TRANSPORT EXPENDITURE BY INCOME GROUP, 2018

Income group	Income stratification	Percentage of employed population	Average monthly income	Direct cost expenditure vs monthly income (%)		
				Public transport	Private transport	Mixed public and private
Low income	<R4 640	47%	R2 400	17%	35%	26%
Medium income	R4 641–R37 100	45%	R14 100	3%	23%	14%
High income	>R37 101	8%	R70 800	1%	9%	7%

Source: City of Cape Town, 2019a.

6.4.6 TRAVEL TIME ESTIMATES

The City has developed an index-based indicator framework called the Urban Development Index (UDI) to assess progress with transit-oriented development annually (see section 6.8) (City of Cape Town, 2019a). Travel time is one of 11 subindices in the UDI and is assessed using 'probe' and 'cordon count' survey data, bus schedules and traffic flow modelling. The UDI estimates travel times for the top five destinations per 1 km^2 grid cell (25 km^2 where data are sparse) distributed across the entire metro. The top five destinations per grid make up more than 75% of all destinations. Despite this, and the prevalence of coarser grid cells for transport indices such as travel time, the results are estimated to be representative of 96% of the employed population. Results for the different transport modes used for trips to work in the morning peak period are shown in table 12.

Strictly speaking, travel time between modes cannot be compared, as the top five destinations vary between grids, and certain destinations are not equally accessible by all modes. Primarily, the data are used to identify areas with long travel times for the modes serving them, such as Hout Bay, Atlantis and the greater metro southeast. However, based on similar return trips plus waiting and walking time, the data reveals that many commuters face total daily travel budgets well in excess of the 90 minutes generally considered tolerable (the so-called Marchetti or Zahavi constant).

TABLE 12: IN-VEHICLE TRAVEL TIMES FROM HOME TO WORK IN MORNING PEAK PERIOD ONLY, 2018

Mode	Average travel time (minutes)	Average minimum travel time (minutes)	Average maximum travel time (minutes)	Share of commuters with trips >45 min
Minibus taxi	39	20	72	30%
Bus	79	26	124	95%
Bus rapid transit	38	24	64	25%
Car	21	7	53	-

Note: Rail travel time data are unavailable. Also excludes waiting times at stops, and walking transitions between stops.

Source: City of Cape Town, 2019a.

6.5 RESPONSES – ELECTRIC AND SMART TRANSPORT

6.5.1 INTRODUCTION

In Cape Town, the transport sector is the biggest energy consumer and carbon emitter, so addressing carbon emissions and meeting the City's carbon-neutrality commitments is key. As the world moves towards more electric-based transport, the interface between the electricity grid and transport becomes increasingly important in mitigating risks and maximising opportunities. This section focuses exclusively on road-based electric mobility (e-mobility) and the challenges and opportunities it presents from an energy and climate change perspective.

The City regards e-mobility and electric vehicles (EVs) as important features of the transport system of the future. They present a unique opportunity to create a healthier and more inclusive city for all by reducing local air pollution, lowering reliance on imported liquid fuels, and developing affordable transport options for all Capetonians. As the proportion of green energy in South Africa's electricity mix increases, EVs also offer a way to reduce overall GHG emissions from transport, allowing the City to fulfil a number of declarations and policy commitments.

E-hailing and ride-sharing services also enable more efficient use of existing transportation and energy resources, and serve as a potential pathway for rapid conversion to EVs in the private sector.

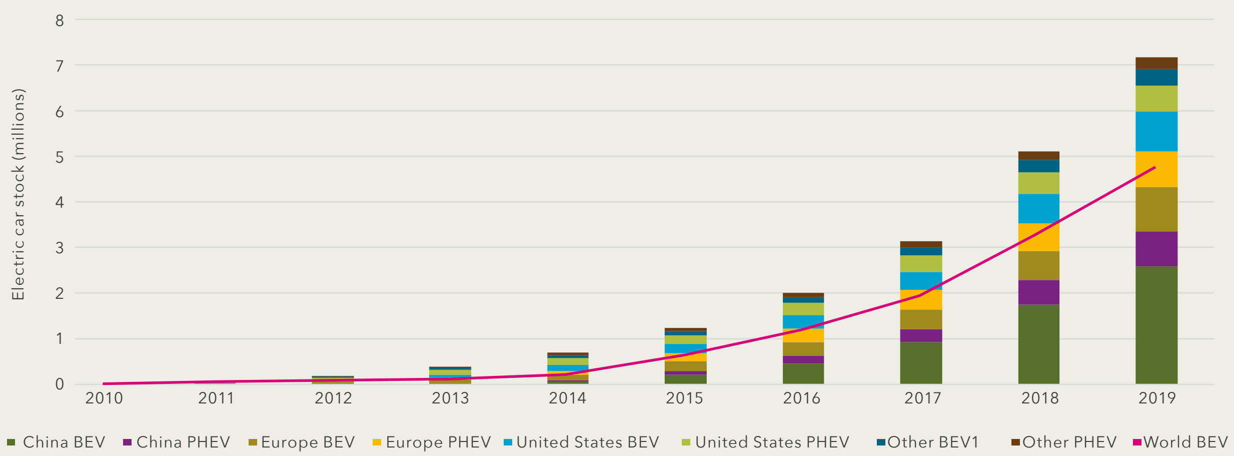
The City aims to facilitate and promote the uptake of EVs in both the public and private sectors through collaboration with stakeholders to understand the challenges and opportunities presented by this process. These stakeholders include City, provincial and national government departments, associations and NGOs, as well as industry manufacturers and service providers. Pilot projects will serve to raise public awareness and provide valuable data on viability to inform future strategies.

6.5.2 E-MOBILITY GLOBALLY

Mobility worldwide is becoming more sustainable, smart and service oriented. EVs, which include private passenger vehicles, electric buses, cargo freights, as well as two-wheelers, such as bicycles, scooters and motorbikes, encapsulate many of these capabilities. The global EV stock is growing, and is replacing traditional internal combustion engine vehicles at a rapid pace (see figure 44 below). Sales of electric cars topped 2,1 million in 2019 and boosted the global stock to 7,2 million (IEA, 2020a). The charging infrastructure that supports these vehicles has followed a similar worldwide trend, as shown in figure 45.

In contrast to internal combustion engine (ICE) vehicles that use liquid petroleum-based fuels, EVs run on electricity stored in a rechargeable battery, giving them a number of advantages over ICE vehicles. Apart from the cost benefits associated with low maintenance and fuel charges, EVs do not directly produce exhaust gases. This means reduced local air pollution in urban areas, where transport vehicles are highly concentrated and exhaust fumes can lead to health risks.

FIGURE 44: GLOBAL ELECTRIC CAR STOCK, 2010–2019



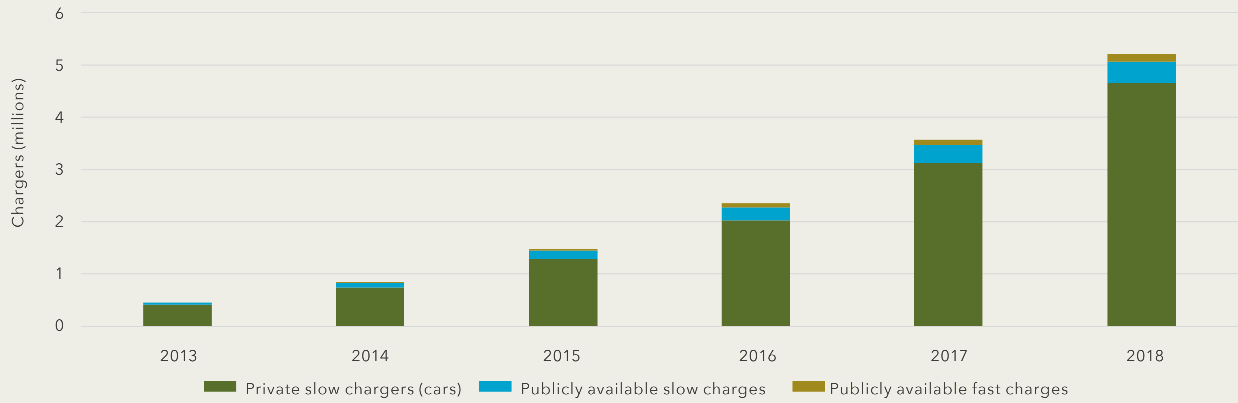
Note: BEV: Battery electric vehicle. PHEV: Plug-in hybrid electric vehicle

Source: IEA, 2020a.

As they run more efficiently than ICE vehicles, EVs charged with South African grid electricity produce 37% less GHG emissions than ICE vehicles, even with the current high carbon intensity of our national grid (Dane, Wright, and Montmasson-Clair, 2019).

With the greening of the electricity grid as more renewables are added to the mix, GHG emissions produced from charging EVs and from the transport sector as a whole will diminish further.

FIGURE 45: GLOBAL INSTALLATION OF ELECTRIC LIGHT-DUTY VEHICLE CHARGERS, 2013–2018



Source: IEA, 2019b.

6.5.3 UNDERLYING POLICY SUPPORT

The City's commitment to encouraging the uptake of EVs and the accompanying infrastructure is supported by various policies and declarations:

- **2015 Paris Agreement**
  South Africa is committed to cutting its carbon emissions and reliance on fossil fuels.
- **Department of Transport's Green Transport Strategy**
  Convert 5% of public and national fleet to cleaner, fuel-efficient vehicles by 2025.
- **The City's Carbon-Neutral 2050 commitment**
  Create a NZC city by 2050.
- **The City's Air Quality Management Plan (2005)**
  Have the cleanest air of any African city.
- **The City's Fleet Management Strategy (2018)**
  Convert 2% of the corporate fleet to zero-emission vehicles by 2030.
- **C40 Fossil Fuel-Free Streets Declaration**
  Procure only zero-emission buses by 2025. Designate a major area of Cape Town as emission-free by 2030.

6.5.4 CITIES AS DRIVING FORCES FOR ELECTRIC VEHICLE UPTAKE

Cities and municipalities are uniquely positioned to forge favourable policy and infrastructure environments to help stimulate the uptake of, and transition to, an electrified transport system in both the public and private sectors (Hall, Moultak, and Lutsey, 2017). Municipalities are also well placed to break possible stalemates between limitations on both the supply and demand side: Demand for EVs remains low in the face of limited supply and charging infrastructure, while supply of EVs and development of infrastructure is limited due to the suppressed market (EcoMetrix Africa, 2016). By implementing a suite of measures, consumers can be both 'pushed' away from traditional ICE technology, and 'pulled' towards EVs (Stevens B, 2013; Nooteboom SG; 2006; Clark R, 2014). Air quality in large, densely populated areas is another leading concern, and a major driver for cities to accelerate the transition to e-mobility. Metros such as London, Paris, Oslo and Beijing have introduced restrictions on highly polluting vehicles and fuels in an effort to improve air quality.

6.5.5 ELECTRIC VEHICLES IN SOUTH AFRICA

EV deployment in South Africa is still in its early phases. By December 2019, there were around 1 000 battery EVs (including plug-in hybrids) and nearly 150 charging stations in the country (uYilo, 2020). The sale of pure battery EVs grew steadily since 2013 and reached 545 units in 2019 (as shown below), although still lagging far behind the rest of the world.

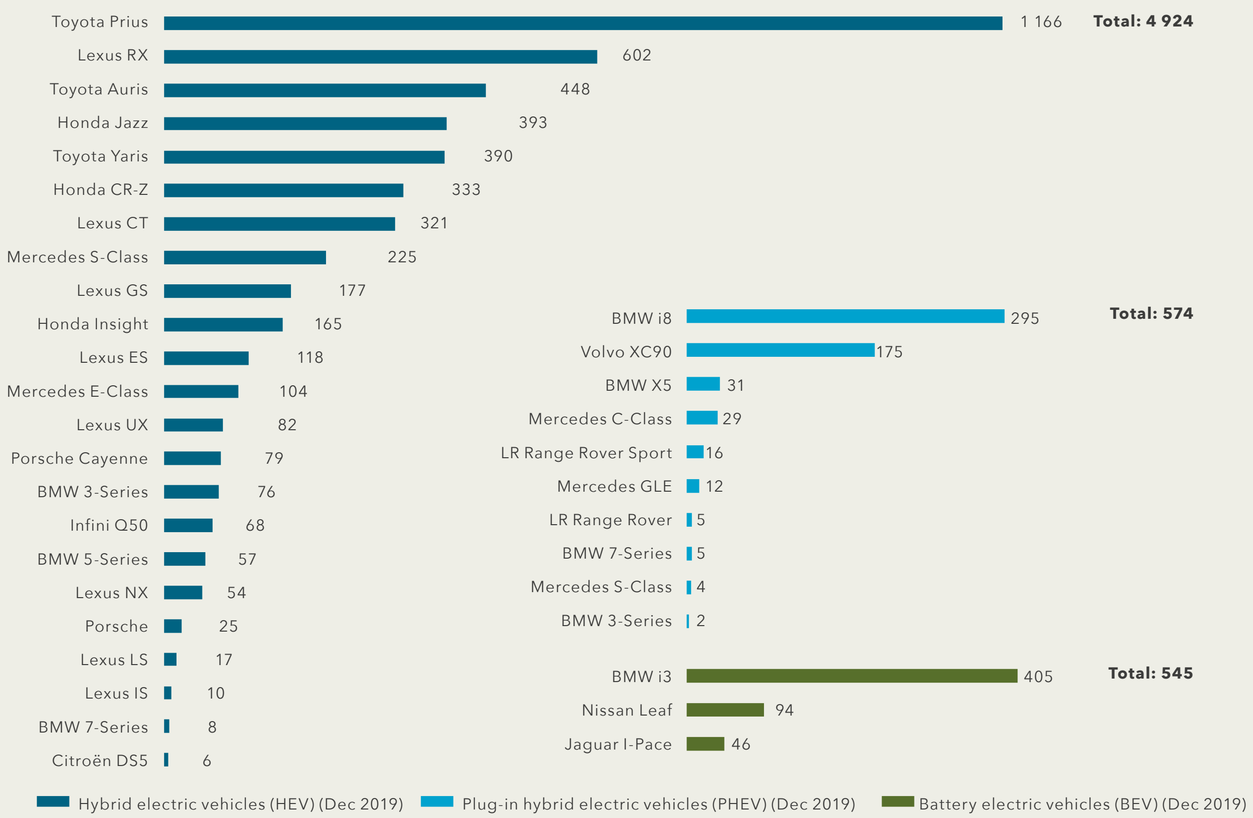
Adopting EVs on a large scale and increasing the green energy in our electricity mix are essential to meet the GHG emission reduction targets to which South Africa has committed. By moving away from ICE vehicles, South Africa will also become more energy independent, and the local economy – most notably food and transport costs – will be less affected by global oil price volatilities. Ultimately, EVs will provide a more cost-effective transportation mode for all.

Nevertheless, EV uptake in South Africa has been lagging behind the rest of the world due to various factors. Although the total price of EVs has been declining worldwide thanks to decreasing battery costs, local prices remain high compared to ICE vehicles. EVs are not currently manufactured in South Africa and have high import duties and taxes due to their status as luxury items: Taxes on imported EVs and hybrids total 42%, compared to only 18% on ICE vehicles (GreenCape, 2020). This, together with a severely limited choice of available EV models, artificially inflates prices beyond what many South Africans can afford. These import taxes are primarily to protect the local vehicle manufacturing industry and accompanying jobs.

The South African automotive industry accounts for 7,5% of South Africa's gross domestic product and employs 113 532 workers in automotive assembly, components and tyre manufacturing (DTI, 2018). Most of the 600 000 ICE vehicles produced in 2018 were bound for the export market (GreenCape, 2020). As the export market for ICE vehicles dries up due to a growing demand for EVs and the worldwide phasing out of ICE vehicles in terms of legislation, South Africa will need to transform its local manufacturing industry accordingly. This will not only preserve the local export market and vehicle manufacturing sector, but will also prevent the accumulation and possible dumping of obsolete vehicles and technologies in the country.

In addition, as National Government is yet to provide clear policy direction and incentives, the EV market is currently still unappealing to outside investors, causing local original equipment manufacturers to continue producing ICE vehicles. Many opportunities exist for a future EV-centred industry in South Africa. Lithium-ion battery production is one such opportunity, as the country already has an established lead-acid battery

FIGURE 46: SALE OF ELECTRIC VEHICLES IN SOUTH AFRICA



Source: uYilo, 2020.

manufacturing and recycling industry, and has key raw materials available (GreenCape, 2020).

It has also been shown that EVs can be locally designed and manufactured. The Joule was a passenger EV produced by Cape Town-based Optimal Energy (Pty) Ltd, established in 2005. Although the project was discontinued in 2012 due to a lack of further funding, it proved the potential for a world-class EV to be produced locally (Venter I, 2012). A local EV manufacturing industry would not only render EVs more affordable, but could also protect jobs and attract investment to the country.

Consumers' current hesitation to purchase EVs is exacerbated by range anxiety[18] and a lack of public charging infrastructure. Prospective buyers are also concerned that South Africa's unreliable electricity supply may pose challenges for EV charging. Yet EV owners and suppliers have confirmed that the impact of load-shedding can be effectively managed, as vehicles typically require only a few hours' charging at night.

As with any large-scale technology change, the shift to the widespread use of EVs comes with a number of potential challenges. Arguments against the uptake of EVs in South Africa include job losses for petrol attendants at fuel stations, the decline in an entire vehicle maintenance market, reduced revenue from fuel levies, and manufacturing job losses as demand for locally produced ICE vehicles declines. However, these potential impacts can be carefully managed with measures such as upskilling and reskilling across the value chain, as well as growing revenue from increased electricity sales. Nevertheless, many of these possible effects are currently unquantifiable due to the infancy of the South African EV market (GreenCape, 2019a).

The global trend, however, is clear: EVs will inevitably become a feature of life and our economy, and South Africa must work towards embracing this.

6.5.6 CAPE TOWN DRIVING THE CHANGE

The City has a number of reasons for supporting the uptake of e-mobility in Cape Town. It offers consumers direct cost savings on vehicle operations and maintenance, as EVs have fewer moving parts than conventional ICE vehicles. EVs also present an opportunity for the City to increase electricity sales, as EV charging will potentially be households' largest electricity need, and even with on-site generation such as solar PV, EV owners will likely stay connected to the grid and continue purchasing electricity, especially for overnight charging. It is also important to keep pace with international trends, which are clearly shifting to e-mobility, thereby shrinking both import and export markets for ICE vehicles.

There are also significant environmental and social reasons. The road transport sector is Cape Town's largest energy consumer and carbon emitter, accounting for 54,4% and 28,7% of the entire city's consumption and emissions respectively (refer to figures 1 and 2). Transitioning to EVs will not only reduce the sector and the city's emissions, but will also improve local air quality and the overall health of Cape Town's citizens, thereby fulfilling the policy objectives outlined above.

Disruptive technologies such as EVs need to be embraced to ensure resilience in an uncertain energy future. If not planned for and managed appropriately, EV technologies may have a negative impact. Therefore, the City needs to pre-empt the implications of a growing EV market, additional electricity consumption and the required charging infrastructure to ensure that the risks are minimised and the benefits maximised for all.

CHARGING INFRASTRUCTURE

Charging infrastructure forms part of the key support

18 The fear that the EV will run out of power before the destination or a charging point is reached.

mechanisms to enable EV uptake. International studies have shown that over 80% of charging occurs in private settings – either at work or at home (Pagania M, 2019). However, without access to adequate public charging infrastructure, potential consumers might be discouraged from investing in an EV due to range anxiety. Countries and cities with extensive public charging infrastructure certainly have higher EV market shares (as outlined above), so boosting charging accessibility for EV drivers could aid the uptake of EVs in Cape Town.

Charging and infrastructure for EVs may be either alternating current (AC) or direct current (DC). AC chargers provide slow charging capabilities, but are cheaper to run and install, as they require little to no specialised equipment. Such chargers are ideal for home, workplace or fleet charging, where EVs will be parked for long periods (throughout the day or night) and can charge slowly. DC chargers, on the other hand, supply rapid charging (approximately 20 minutes to charge fully), but are expensive to run, and require dedicated equipment to install. These would be best suited for dedicated stations where motorists need a quick top-up charge, such as along highways and at strategic points around town (Advanced Energy Economy, 2018).

South Africa currently has over 250 charging stations, with just over 50 in the Western Cape, mostly centred in Cape Town (PlugShare, 2020). Charging infrastructure is also available along the N1 and N2, which enables EV thoroughfare between Cape Town and Johannesburg. The City, the Western Cape government and Eskom have identified the three national routes – the N1, N2 and N7 – as optimal locations for further EV charging stations, at 80 km intervals.

IMPACT ON THE CITY'S ELECTRICITY SUPPLY AND GRID

Shifting transport energy to electricity through an increase in EV usage will drive up electricity consumption. This could provide the City with an opportunity to increase revenue from electricity sales, and to lower the City's reliance on imported fossil fuels and, therefore, its exposure to the price and availability fluctuations associated with imported fuels. However, the shift also presents challenges to the integrity of the network.

As with SSEG, some of the biggest challenges that the City may face with EVs are at the interface with the electricity network. However, even with high penetration of EVs, the increased electricity demand nationally could be managed through proactive planning, 'smart' system operations and user incentives, to the extent that no additional electricity generation capacity would be required (Dane, Wright, and Montmasson-Clair, 2019). As most charging is expected to occur at homes or businesses, the greatest potential impact is likely to be on low-voltage distribution grids in residential and commercial areas (IEA, 2017). Therefore, it is critical that EV charging infrastructure is safe, poses no threat to grid stability, and can be effectively managed through smart-enabled equipment to avoid surges, demand challenges and localised grid problems. Regulations to govern the safety risks, interoperability and network capabilities of charging infrastructure need to be implemented at a national level, and the City actively supports the development of such regulations through engagements with relevant government and private-sector players.

In the future, EVs are also likely to play an important part in demand management and storage through vehicle-to-grid or two-way charging capabilities: EVs can provide the power stored in their batteries back into the grid when capacity is needed. This dynamic buying and selling of electricity will be enabled by smart grid technologies and real-time pricing that escalates as the grid becomes more constrained. This will also encourage users to charge their vehicles at off-peak times, when demand is low and excess generation is not utilised.

IMPACT ON AIR QUALITY

The Air Quality Management Plan outlines the City's mission "to reduce the health effects of poor air quality on the citizens of Cape Town, especially during 'brown haze' episodes". Specifically mentioned in the plan is the objective to control vehicle emissions in Cape Town, which directly relates to EVs. Studies (Wicking-Baird M, 1997) have shown that vehicular exhaust gases are the main cause of Cape Town's infamous 'brown haze' – episodes of visible air pollution. Shifting from ICE vehicles to EVs will help the City achieve its clean-air commitment by eliminating vehicle exhaust fumes, thereby reducing the harmful effect of air pollution on citizens' health, and improving Cape Town's liveability and appeal to both tourists and residents.

CASE STUDIES

It is important for the City to lead by example in setting the standards and norms for a decarbonised future. While early EV adopters are expected to be private passenger vehicles in more affluent areas, converting a portion of the City-owned fleet can facilitate the uptake of EVs in Cape Town by creating demand and learning through doing.

- **Installation of public EV charging stations**

As part of its support for EV uptake across Cape Town, the City launched two new public EV charging stations – one at its Bellville civic centre in December 2020, and the other at the Somerset West municipal building in March 2021. These chargers have been donated by the United Nations Industrial Development Organisation as part of their Low-Carbon Transport-South Africa project and are free for the public to use for their first two years of installation.

Both charging stations are accompanied by grid-tied solar PV systems, which feed into each building's electricity network. Although the chargers are not solely powered by renewable energy, any electricity drawn from the grid is offset by electricity generated by the PV panels that is fed back to the building. The solar panels highlight the link between electrified transport and renewable energy, and the importance of developing them in tandem. Along with creating accessible charging infrastructure for the public, this pilot project will provide the City with valuable experience in rolling out public EV charging infrastructure. In the course of the pilot, real-world data on user behaviour, charging station operations and costs, as well as general feasibility feedback will be gathered and used to inform future projects.

- **Study on impact of EV infrastructure**

To understand the implications of widespread EV charging infrastructure for the City's grid, EGD undertook a detailed study through ETH Zürich in 2019. The study identified 208 potential locations across Cape Town for public EV charging infrastructure, including at shopping malls and filling stations, and prioritised key areas based on load factors. The study also modelled substation demand due to home EV charging at various levels of EV uptake. An EV penetration level of 2,5% caused an increase of 253 MWh in daily electricity demand due to charging across town, with most substations experiencing an increase of 3 to 5 MWh. At a 5% penetration rate, the electricity demand due to public charging saw a modest increase. Areas that saw the highest increase in demand were Helderberg and Langverwacht (Kuils River). It was also found that demand from home charging would be up to three times higher than that from public chargers, as EV users tend to charge at home. These findings will help inform the City's strategies to enable EV charger roll-out and prepare the electricity grid for widespread EV charging.

- **Cost benefit study on City fleet conversion**

The City's Economic Opportunities and Asset Management Directorate seeks to convert 2% of its fleet to EVs by 2030. In 2019, the City commissioned a study by Royal HaskoningDHV to gain a better understanding of the cost feasibility of transitioning the City's fleet to electric, and supplemented the study with its own further investigation.

Results showed that for a number of vehicles currently operated by the City, switching ICE vehicles to a similar electric model was a financially viable option, particularly for those vehicles with high capital costs and annual mileages. The study found that cost parity for EVs is expected to be reached in 2025, by which time a full fleet conversion to EVs will make sense both financially and environmentally.

It was recommended that more real-world data be gathered to gain insights on how fleet operators would experience a shift to EVs. This would provide more accurate data to assess the feasibility of transitioning to EVs, raise awareness of the importance of the transition, and highlight potential challenges that would need to be addressed.

- **City fleet EV pilot project**

Following the results of the cost benefit studies above, the Economic Opportunities and Asset Management Directorate procured five EVs in 2020 for use by the Safety and Security Directorate. The vehicles were specifically chosen for this role and were comparable to non-electric vehicles in terms of both price and performance. The EVs each cost just over R500 000, while their ICE counterparts cost R460 000 to R550 000.

While still in its initial phase, this roll-out shows that the City is leading by example, demonstrating to the public the viability of this technology, and sending a message to original equipment manufacturers that the demand exists. The roll-out also enables the City to monitor the performance of the vehicles, which can inform future decision making on the expansion of the EV fleet.

- **Tariff investigation**

Electricity tariff structures can have a significant effect on user behaviour and can be designed to achieve different outcomes, such as to minimise negative impacts on the electricity network. While EV-specific tariffs have not been shown to drive uptake, progressive, cost-efficient tariff structures can help make EVs a more realistic choice for customers, and can encourage off-peak usage to reduce electrical demand and strain on the grid.

A study commissioned by the City and funded by the Friedrich Naumann Foundation investigated a potential electricity tariff structure for EVs in Cape Town. The study, conducted by Change Pathways, concluded that tariffs targeted specifically at EV users were unlikely to be implemented, although an opt-in time-of-use tariff for all residential customers was a longer-term goal as electricity tariffs became more cost-reflective. The findings also highlighted the need for clarity as to what the objectives of the tariff would be in terms of shaping and managing the EV landscape, grid structure and customers, and recommended further investigations and the gathering of real-world data.

- **Electric bus roll-out**

Electric buses have seen rapid international growth and made a large impact on public transport networks in various cities across the world. The demand for transport services in Cape Town will only grow in the coming years, and public transport presents the best business case for electrification. Currently, 38% of morning peak trips in Cape Town are made on public transport, with some 95% of public transport users being in the low to low–middle income brackets. Therefore, public transport is many Capetonians' main and often only way of getting around. Thus, the challenge the industry faces is to reduce the environmental impact of the sector, while delivering improved mobility.

As part of the C40 Fossil Fuel-Free Streets Declaration and through the MyCiTi integrated rapid transit system, the City is using public transport to achieve a more efficient and sustainable Cape Town, while offering a service that is affordable, dignified and safe. The municipality remains committed to the transition to electric bus, taxi and passenger vehicles by 2050 so that Cape Town can become part of the international green economy.

6.5.7 E-HAILING AND RIDE SHARING

Over the past few years, e-hailing and ride sharing have rapidly emerged as innovative transport options, combining existing infrastructure with digital portals and mapping so as to optimise trips and use vehicles more efficiently. If these services become as convenient and cost-effective as personal car ownership (or even more convenient and cost effective), total personal vehicles would decrease, as would the potential for traffic congestion and energy usage – goals that are all in line with the City's various policies outlined above. However, there is conflicting evidence as to whether ride sharing eases traffic congestion, and how it may affect energy consumption. These factors may depend on the specific city, and although there is a growing body of research, no definitive conclusions have yet been reached.

E-hailing and ride sharing also offer a way for the rapid electrification of private transport. Platform operators set strict limitations on the age of vehicles used for these services, creating a high vehicle turnover, and the potential for this sector to become early adopters of EVs. Companies in this sector are currently investing in expanding the share of EVs in their operating fleets: Uber, for instance, has partnered with a number of NGOs and drivers to introduce EVs into various cities in the United States. In 2020, they also committed to 100% of their global fleet being electric by 2040, and pledged to help drivers finance the transition.

Uber and Bolt (formerly Taxify) are the two main ride-hailing operators in South Africa, and both offer potential markets for EV penetration. In 2016, Uber launched the UberGREEN pilot project, where riders in Johannesburg and Cape Town could choose to hail rides using EVs at no extra cost. The project proved successful and clocked up over 5 300 km of trips made, which confirmed a willing South African market for private e-mobility options (BusinessTech, 2016).

6.5.8 CONCLUSION

The global momentum that has been gathering in terms of EVs indicates that South Africa needs to be ready to embrace this technology. The City sees the uptake of EVs as a critical opportunity to improve local air quality, reduce GHG emissions from transport, and meet the various climate change commitments made towards carbon neutrality by 2050.

In developing an enabling environment for the uptake for EVs, the City is leading by example in its own fleet, supporting the installation of charging infrastructure, working to understand the impacts on the grid, and collaborating with relevant role players on policies and regulations.

6.6 RESPONSES – LEARNING FROM THE JOURNEY: MYCITI PHASE 2A

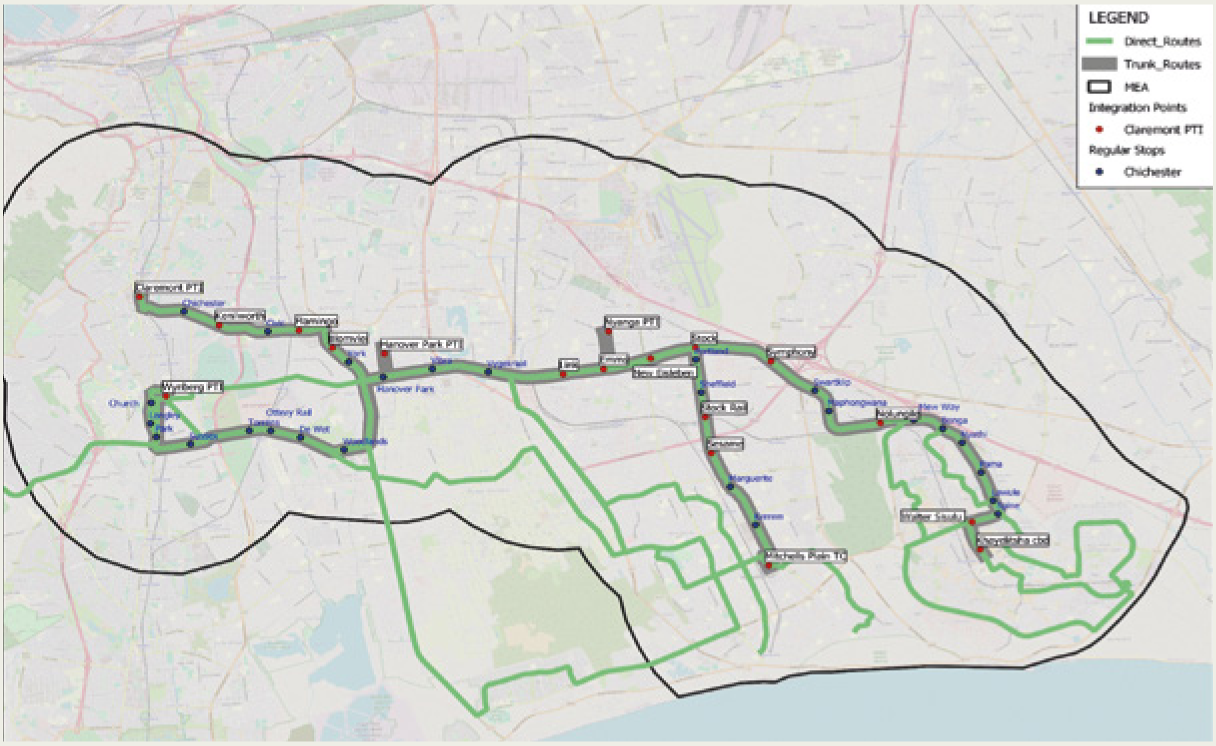
The next phase of expansion of the MyCiTi scheduled bus service is known as Phase 2A and will provide services from the metro southeast of Cape Town to the central business district (CBD) node of Claremont/Wynberg, as shown in figure 47 below.

This development has the potential to bring a high-quality scheduled transport service to low-income areas of Cape Town in need of investment, opening up opportunities and driving local business growth. Yet this already ambitious and technically demanding project also faces the challenge of integrating the existing minibus taxi paratransit system, and undertaking construction, operations and securing assets in socially volatile areas of town.

The spatial form of Cape Town, which is characterised by long distances between dense neighbourhoods and job opportunities, and with low densities and little commercial activity along the connecting corridors, creates tidal flows with high peak demands. Unscheduled minibus taxi services have evolved over time to meet this demand without subsidy. This makes the design and integration of a scheduled, economically sustainable bus system very challenging. A key decision is what service pattern or combination of patterns to apply. The two main patterns are shown in figure 48. In so-called 'trunk-and-feeder' systems, feeders operate from and to different origins and destinations in mixed traffic on local streets, and converge on a single terminal, which feeds a so-called bus rapid transit (BRT) corridor (usually a dedicated lane) that operates at higher frequencies and speeds. With direct services, in turn, routes include mixed traffic on local streets, and enter the BRT corridor without transfer. These patterns represent a trade-off between the economy of scale of larger vehicles with high occupancies that could be achieved in a trunk-and-feeder system on the corridor, and the reduction of peak demand and overall high ridership (due to convenience) that could be achieved with direct services that do not require transfers.

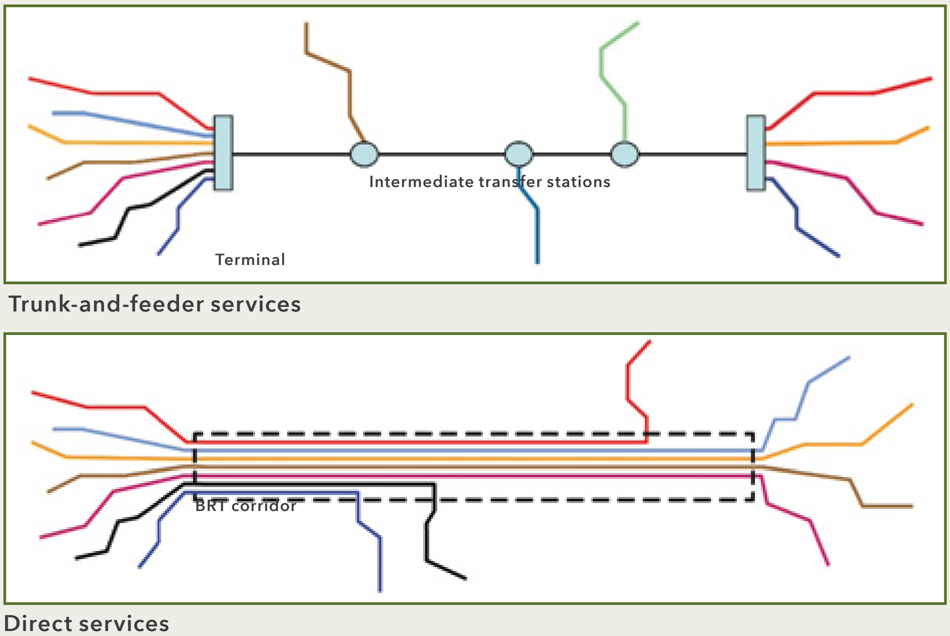
In meeting the challenges of integration and system design, Phase 2A will apply the valuable lessons learned from MyCiTi Phase 1 as outlined in the section below (City of Cape Town, 2020a).

FIGURE 47: PLANNED INTEGRATED RAPID TRANSIT PHASE 2A STATION AND STOP LOCATIONS ALONG MAIN ROUTES



Source: City of Cape Town, 2021.

FIGURE 48: COMPARISON OF THE TWO MAIN SERVICE PATTERN DESIGNS FOR BUS SYSTEMS



Source: ITDP.

6.6.1 INTEGRATION AND SERVICE PATTERN OF PHASE 2A: THE HYBRID NETWORK MODEL

The BRT model adopted successfully in many developing countries usually involves a process whereby incumbent paratransit operators, operating in an unscheduled manner, are integrated with the new system as shareholders. In the South African integrated public transport programmes undertaken in a few major cities since 2010, this has generally occurred through the formation of vehicle operating companies (VOCs). However, a considerable number of minibus taxi operators were, instead, compensated for their operating licences through schemes that varied from one city to the next. Compensation was premised on the understanding that they would cease to operate, but many later returned in direct competition with the system.

The Phase 2A approach will not be to replace all existing services. Feeder routes will not constitute scheduled MyCiTi services, but will rather leverage the flexibility and coverage of minibus taxis, supported by some incumbent Golden Arrow bus routes, in what is known as a hybrid network model. In any event, planning has shown that it would be unaffordable to serve 100% of the metro southeast corridor demand. Therefore, the MyCiTi service expansion is designed to meet around 65% of the Phase 2A system demand, with the remainder served mainly by minibus taxis on feeder routes.

The hybrid network model will also combine direct routes with main route services. These direct routes integrate pre-existing routes with the main corridor to provide a significant share of ridership with the option of alighting and departing closer to their origin and destination points, without the delay of transferring from a feeder to a main route. Phase 1 demonstrated the large demand for express services because of the spatial form of Cape Town, which causes tidal flows between just a few nodes at peak times. Therefore, express services are being designed into Phase 2A from the start.

The preferred business and incentive models for the VOCs operating the main and direct routes, and the proposed institutional arrangements for the feeder services, are outlined in an industry transition business plan (City of Cape Town, 2021). Minibus taxi operators with operating licences that have points of origin in the MyCiTi expansion area that encompasses Phase 2A are potentially eligible to acquire equity in the two minibus taxi-based VOCs planned for this area. Long-term contracts for MyCiTi Phase 2A services will be negotiated with these VOCs, and with Golden Arrow bus service.

For feeder routes, a moderate level of formalisation is proposed whereby association-based companies coordinate the supply of MyCiTi feeder requirements in response to an allocation per company, so that incentives are not too diluted. However, other models are defined and may be implemented depending on associations' appetite.

6.6.2 ENGINEERING, OPERATIONS AND SYSTEM CONSIDERATIONS

Phase 1 has provided many lessons for engineering, operations and system design in the local context, including the following:

RELIABILITY/PREDICTABILITY AND SPEED:
A key principle of successful BRT systems has been dedicated lanes, which has been seen with Phase 1. This creates a speed advantage for public transport, ensuring ridership and making the system less vulnerable to the unpredictable delays of mixed traffic.

BUS TYPOLOGIES:
Phase 1 employed high-floor buses on main routes, and low-floor buses on feeders. This reduced system flexibility and increased the complexity of interchanges. Phase 2A will use only low-floor buses with doors on both sides.

EXISTING PUBLIC TRANSPORT INTERCHANGES:
These will be key system nodes where unscheduled feeders can link to the Phase 2A system.

STATION COMPLEXITY:
The running costs of enclosed stations have been a large cost driver in Phase 1. For this reason, open stations are included in Phase 2A wherever appropriate, considering demand and safety. Vandalism of Phase 1A stations led to instances of shutdown, so vandalism-resistant design is being pursued for Phase 2A.

REGULATION AND ENFORCEMENT:
Enforcement of the agreements concluded with minibus taxis had poor success in Phase 1. While the City recognises that enforcement alone cannot address route competition, the development of enhanced enforcement approaches and capacity will be required.

6.7 RESPONSES – TRANSIT-ORIENTED DEVELOPMENT

Efficient mass transit is key to curtail the energy demand of transport, its local air pollutant and GHG emissions, as well as other externalities such as accidents and congestion. Transit-oriented development (TOD) is an integrated approach to city planning where spatial planning and urban management support viable and efficient mass transit, which, in turn, underpins functional and economically vital neighbourhoods and precincts. TOD has been described as "compact, mixed-use, pedestrian-friendly development organized around a transit station. TOD embraces the idea that locating amenities, employment, retail shops, and housing around transit hubs promotes transit usage and non-motorized travel" (Suzuki, Cervero, and Iuchi, 2013). The TOD approach of integrating where people live with where they work and how they move is captured in the eight standard principles in table 13.

For a developing city such as Cape Town, with a legacy of urban sprawl, the expansion of economically viable, high-quality mass transit depends on densification, which should be strategically located along transport corridors. In this regard, the City's Comprehensive Integrated Transport Plan notes: "TOD is about changing, developing and stimulating the built form of the city so that the movement patterns of people and goods are optimised in order to create urban efficiencies and enable social equality and economic development" (City of Cape Town, 2020a).

TABLE 13: THE EIGHT STANDARD PRINCIPLES OF TRANSIT-ORIENTED DEVELOPMENT

WALK

DEVELOPING NEIGHBORHOODS THAT PROMOTE WALKING

OBJECTIVE A.
The pedestrian realm is safe, complete and accessible to all.

OBJECTIVE B.
The pedestrian realm is active and vibrant.

OBJECTIVE C.
The pedestrian realm is temperate and comfortable.

MIX

PLAN FOR MIXED USES, INCOME AND DEMOGRAPHICS

OBJECTIVE A.
Opportunities and services are within a short walking distance of where people live and work, and the public space is activated over extended hours.

OBJECTIVE B.
Diverse demographics and income ranges are included among local residents.

CYCLE

PRIORITISE NON-MOTORISED TRANSPORT NETWORKS

OBJECTIVE A.
The cycling network is safe and complete.

OBJECTIVE B.
Cycle parking and storage is ample and secure.

DENSIFY

OPTIMISE DENSITY AND MATCH TRANSIT CAPACITY

OBJECTIVE A.
High residential and job density support high-quality transit, local services and public space activity.

CONNECT

CREATE DENSE NETWORKS OF STREETS AND PATHS

OBJECTIVE A.
Walking and cycling routes are short, direct and varied.

OBJECTIVE B.
Walking and cycling routes are shorter than motor vehicle routes.

COMPACT

CREATE REGIONS WITH SHORT TRANSIT COMMUTES

OBJECTIVE A.
The development is in, or next to, an existing urban area.

OBJECTIVE B.
Travelling through the city is convenient.

TRANSIT

LOCATE DEVELOPMENT NEAR HIGH-QUALITY PUBLIC TRANSPORT

OBJECTIVE A.
High-quality transit is accessible by foot. (TOD requirement)

SHIFT

INCREASE MOBILITY BY REGULATING PARKING AND ROAD USE

OBJECTIVE A.
The land occupied by motor vehicles is minimised.

Source: ITDP, 2017.

6.7.1 THE BUILT ENVIRONMENT PERFORMANCE PLAN LEGACY – INTEGRATION ZONES

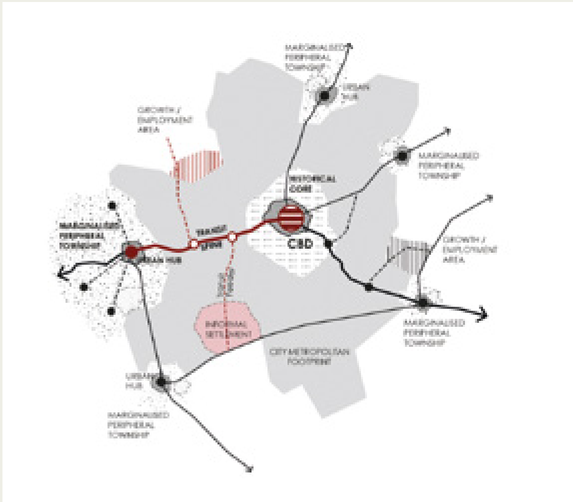
To drive spatial transformation in South Africa's cities, National Treasury introduced the built environment performance planning process for metros in the 2011/12 financial year, serving as an eligibility requirement for the Urban Settlements Development Grant (National Treasury, 2017a). By 2014, the process had led to ambitious plans for restructuring the built environments of all the country's metros. The Built Environment Performance Plan (BEPP) aimed to align built environment grants around not only a vision, but also a portfolio of targeted and practical public investment projects and regulatory reforms.

Targeted investment meant identifying the key elements of urban networks – settlements, transit corridors and areas of economic activity – and integrating them functionally. This was formalised as so-called integration zones.

An integration zone is a branch of an urban network. It consists of a transit spine and a number of targeted 'anchor' and 'intermediate' nodes, as well as transport feeder linkages to secondary township nodes, marginalised residential areas (usually informal) and commercial/industrial areas (employment sites), as illustrated in figure 49 (National Treasury, 2017b).

Although the City has now received Treasury exemption from developing an annual BEPP, integration zones remain fundamental to the municipality's spatial development framework and Catalytic Land Development Programme, as discussed next.

FIGURE 49: CONCEPTUAL PRIORITY INTEGRATION ZONE (RED) IN AN URBAN NETWORK



Source: National Treasury, 2017b.

6.7.2 SPATIAL DEVELOPMENT PLANNING – THE 'BLUE TURTLE'

The City's IDP highlights the need for spatial transformation. This is also supported by a number of other City planning documents, including the TOD strategic framework, which outlines the integration of transport and spatial planning features at different scales of the built environment – from large-scale metropolitan zones, to corridors connecting large-scale areas of activity, to local-area nodes supporting the corridors, to precincts in nodes where key infrastructure and facilities are located (City of Cape Town, 2016). These concepts were carried through into the Municipal Spatial Development Framework (City of Cape Town, 2018), which combined them into a vision that shows how key nodes of development can be coherently linked by transit corridors, as shown in figure 50.

Known colloquially as the 'blue turtle', the City's spatial planning concept defines four investment zones:

URBAN INNER CORE (BLUE):
This turtle-shaped core area is framed by the three integration zones – the Voortrekker Road corridor, the metro southeast corridor and the Blue Downs/Symphony Way corridor – as well as the planned Phase 2A MyCiTi route (see inset in figure 50). The City is committed to spatially targeting investment and development in this zone.

INCREMENTAL GROWTH AND CONSOLIDATION AREAS (ORANGE):
The City is committed to servicing existing communities, while new development is subject to infrastructure capacity.

DISCOURAGED GROWTH AREAS (GREY):
No investment by the City.

CRITICAL NATURAL AREAS (GREEN):
The City is committed to servicing, protecting, enhancing and extending these critical natural assets.

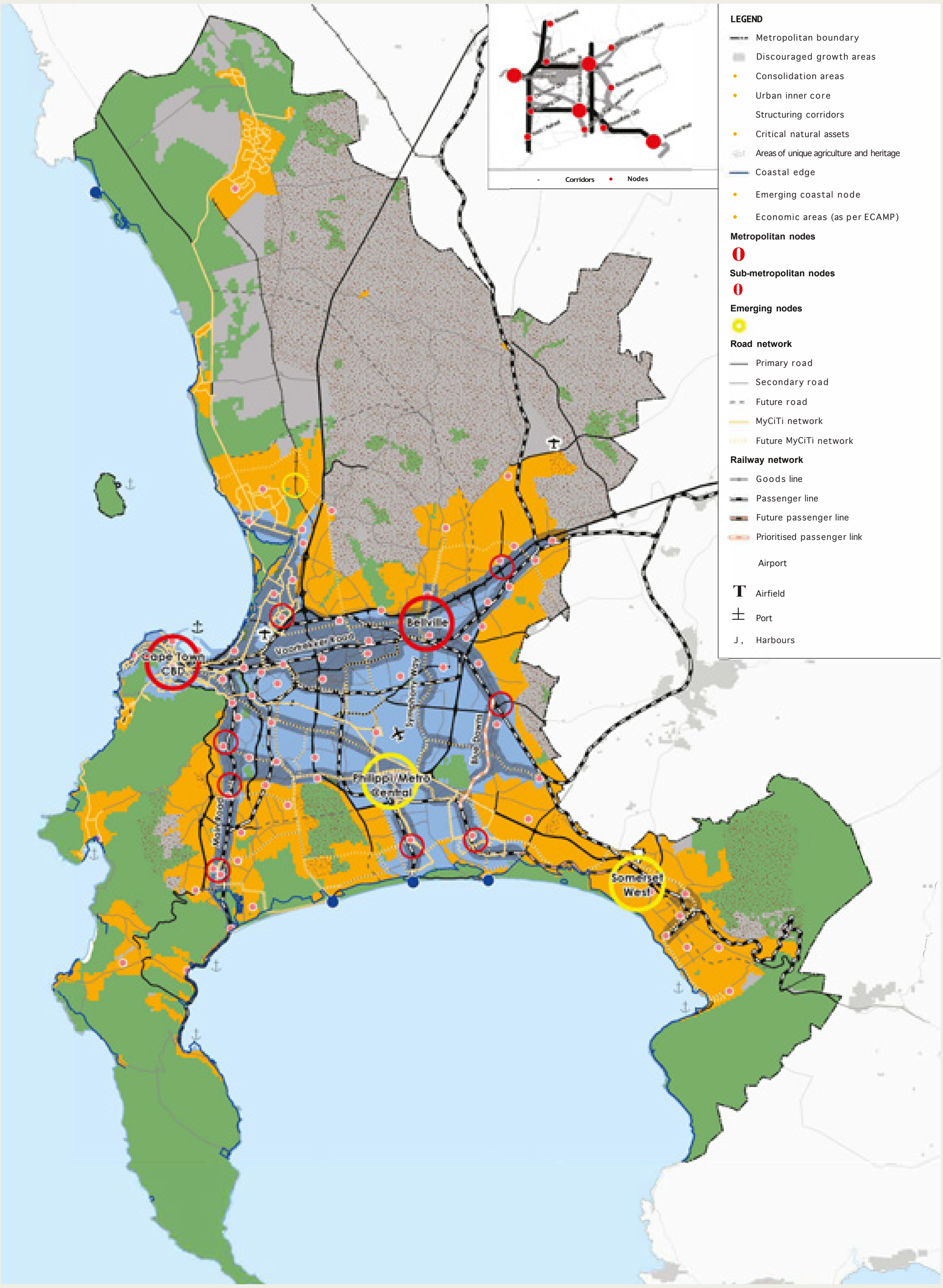
Consequently, the following principles are applied to all new and existing development decisions, spatial strategies, tools and policies to support TOD and spatial transformation (City of Cape Town, 2020a):

- Bulk infrastructure investment will be prioritised in the urban inner core and, generally, in the existing urban footprint.
- High-density, high-intensity mixed-use development will be prioritised along the MyCiTi main routes and in the rail station precincts, with the 42 MyCiTi and 98 rail stations being catalysts for development and redevelopment. Minimum densities of 80 dwelling

units per hectare will be targeted in these locations, comprising a variety of typologies, tenure models and affordability levels.

- Integration of innovative inclusionary housing will be pursued in the inner-city urban cores, including Khayelitsha, central Cape Town, Claremont, Mitchells Plain, Wynberg and Bellville.

FIGURE 50: THE CITY OF CAPE TOWN'S INTEGRATED PLANNING CONCEPT



Source: City of Cape Town, 2020a.

6.7.3 CATALYTIC LAND DEVELOPMENT PROGRAMME (CLDP)

To varying degrees, the integration zones that frame the urban inner core and contain the CBD and urban hub nodes (refer to figure 49) lack critical mass or have deteriorated over time as investment located elsewhere. These then present an opportunity for spatially targeted regeneration by the City through bulk infrastructure investment and the unlocking of public land around transit stations. This project portfolio and infrastructure implementation pipeline is being planned and implemented through the Catalytic Land Development Programme (CLDP). The programme targets the following three levels:

- Public land development opportunities around prioritised BRT and train stations with a high ridership, in partnership with PRASA and other role players
- A portfolio of so-called level 2 TOD initiatives in local transit-accessible secondary precincts and nodes
- Three metropolitan-scale priority TOD catalytic projects, namely the Bellville CBD opportunity area, the Philippi opportunity area, and the Foreshore precinct, which were identified following a process of rationalisation. However, the City recognises the importance of other sites in the medium and longer term, such as Paardevlei in the southeast and the Athlone power station site.

The three priority sites have the following features:

BELLVILLE CBD OPPORTUNITY AREA:
This area represents a major confluence of passenger and freight transport arteries and interchanges around a historic central business district (Bellville city centre). Major features include the N1 highway, the Voortrekker Road corridor-long commercial frontage with housing behind, the freight rail utility Transnet's Belcon complex, significant City landholdings, a taxi rank, and a metropolitan rail station. These represent considerable opportunities for the development of a multimodal transport interchange with adjoining and overhead commercial property development, clustering of public facilities, and densification through infill housing.

PHILIPPI OPPORTUNITY AREA:
This project aims to support the MyCiTi Phase 2A expansion with TOD investments around the bus and integrated rail stations. These include the currently closed Nolungile station to the north of the Swartklip site, which is owned by ACSA. Coupling upgrades to the airport precinct with public investment in the areas to the south, the bold concept of an 'aerotropolis' aims to leverage one of Africa's busiest airports to stimulate localised economic growth and social development.

FORESHORE PRECINCT:
The Foreshore's incomplete freeway has long been a planning controversy, and a solution will be pursued, with the viability of completing the inner viaducts being explored. Considerable public landholdings in the vicinity offer opportunities for the exchange of development rights to unlock investment, including increased housing provision in the inner city. The abutment with other planned public land redevelopments, including the port and the Department of Public Works' Customs House, presents considerable additional opportunities.

6.8 RESPONSES – THE URBAN DEVELOPMENT INDEX

TOD requires targeted and sustained large-scale investment over long time periods to succeed. Projects are complex, expensive and high-risk. While challenging given the multiple facets and spatial complexity involved, tracking the progress throughout Cape Town over time is essential. This is why the City has developed the UDI to measure the level of integration and spatial transformation in town. The UDI consists of 11 sub-indices, organised around three key pillars of TOD, as shown in table 14.

The UDI is characterised by a transparent data methodology, which can be implemented either internally or by contractors. As briefly described in section 6.4.6 above with regard to travel times, the index adopts a highly spatialised approach to maximise the share of the population it represents, and to identify problem areas at a reasonable resolution.

TABLE 14: THE 11 SUB-INDICES OF THE URBAN DEVELOPMENT INDEX TO SHOW PROGRESS WITH THE IMPLEMENTATION OF TRANSIT-ORIENTED DEVELOPMENT OVER TIME

A. Transport measures	B. Land-use measures	C. Housing measures
• Travel time (all modes) • Travel distance (all modes) • Modal split • Direct costs • Congestion levels • Flexibility	• Jobs vs residents • Residential density along PT routes • Employment density along PT routes	• Housing price diversity index • Informality

Source: City of Cape Town, 2019a.

6.9 OPTIONS – THE PROS AND CONS OF NATURAL GAS

The City signed a grant agreement worth more than R12,7 million with the United States Trade and Development Agency to conduct a feasibility study on a natural gas distribution network for Cape Town. The regional availability of natural gas offers an opportunity to achieve a greater mix of energy sources and, critically, to support a higher share of variable renewable electricity.

The study evaluated a gas distribution system utilising liquefied natural gas (LNG) importation, assuming a system configuration involving an LNG import facility at Saldanha Bay, a high-pressure gas transportation main line having two segments, and a low-pressure two-phase distribution and reticulation pipeline system. Implementing LNG importation and transmission as part of such a gas supply system would require coordination between the City, the Western Cape Government, a number of national regulators and parastatals, as well as a number of project developers. Completed at the end of 2019, the study found that imported LNG was not feasible as an energy supply for Cape Town at the time. The anticipated volume of demand was not anticipated to support the high fixed costs of pipeline infrastructure required, or to be sufficient for advantageous supply contracts.

This finding, however, needs to be reconsidered in light of the DMRE's recent award of the Risk Mitigation Independent Power Producer Procurement Programme. The programme aims to address the national electricity supply gap from a range of supply technologies and move away from diesel-fuelled peaking power (DMRE, 2020). Importantly, the DMRE has expressed the following view:

"The introduction of natural gas in the broader South African energy mix is an important step in our energy transition. The FSRU1[19] infrastructure at the ports can be used as a stepping stone to enable further opportunities for local industrialization and manufacturing that are currently utilizing higher cost fuel, as recognised in the IRP2019." (DMRE, 2020)

The largest share of capacity was awarded to the Turkish-based Karpowership, which provides ship-based power plants that can be quickly deployed in existing port infrastructure. Their bid included 450 MW in Richards Bay, 450 MW in Coega in the Eastern Cape, and 320 MW in Saldanha Bay, 111 km north of Cape Town (DMRE, 2021). Yet the award of this bid is currently mired in controversy after an unsuccessful bidder objected, and the environmental assessment process

19 Floating storage regasification unit – a temporary installation used to disembark liquefied natural gas into storage.

has subsequently been suspended (Carnie, 2021).

The roll-out of the required off-take and storage infrastructure and an anchor client in the form of the power plant potentially changes the economic equation locally. However, while natural gas has been touted as a 'transition fuel' to a low or carbon-neutral future, any overall benefit is contingent on keeping fugitive emissions low (Merven, et al., 2017), which gets increasingly difficult as a gas system grows. Cape Town's carbon-neutral ambitions preclude a long-term commitment to natural gas outside of the support role for renewable-electricity plant that cannot practically be filled by battery storage. Therefore, the City will have to reconsider its position regarding natural gas, should the Karpowership bid be implemented.

6.10 OPTIONS – THE HYDROGEN ECONOMY

When hydrogen is combusted or used electrochemically in a fuel cell to produce electricity, it produces no direct emissions other than water vapour. Therefore, the urgent need to mitigate GHG emissions is driving research and development in the field of hydrogen technologies worldwide. This investment, and the subsequent scaling of new production, distribution and demand technologies, could see hydrogen as the clean, secure and affordable fuel of the future for hard-to-decarbonise sectors such as freight transport and industrial heating (van Hulst, 2019). Many countries and companies have joined the Hydrogen Council, as well as the Intergovernmental Partnership for Hydrogen and Fuel Cells in the Economy, of which South Africa is a member.

While not occurring readily on its own, hydrogen is the most abundant element in the universe, being a constituent of water molecules and all fossil fuels. In the latter case, it is bound to carbon, which results in CO_2 emissions when combusted. As a result, hydrogen must be separated from water, biomass or fossil fuels, requiring energy-intensive processing, which will also be carbon intensive if the fossil fuel carbon is not captured and the input energy is not renewable. Therefore, not all hydrogen is created the same. Although hydrogen is actually a colourless gas, it is commonly colour referenced to denote its cleanliness. Grey (natural gas derived) and brown (coal derived) hydrogen causes significant amounts of CO_2 in the production process, and accounts for most hydrogen currently produced globally. If carbon capture and storage technologies are utilised to reduce CO_2 emissions, the hydrogen is shown in blue. Green hydrogen, produced from the electrolysis of water, using renewable electricity, is the cleanest form of hydrogen, with zero emissions. Therefore, abundant and cheap renewable electricity is key to the availability of affordable green hydrogen.

Hydrogen has a very low density and is challenging to store and transport, requiring very high pressures. While indications are that hydrogen can practically be used in road freight transport with reasonable vehicle range, especially if combined with batteries, it is not easily applied in aviation and shipping. These drawbacks can be addressed either through production and use on-site, where possible, or using the hydrogen along with other chemicals, including renewable or captured carbon, as an input to a refinery that produces a range of fuels similar to what we use today. These green powerfuels or carbon-neutral molecular fuels enable the so-called 'Power-to-X' concept, whereby renewable electricity can be indirectly used in a large range of new applications, decarbonising them as shown in figure 51.

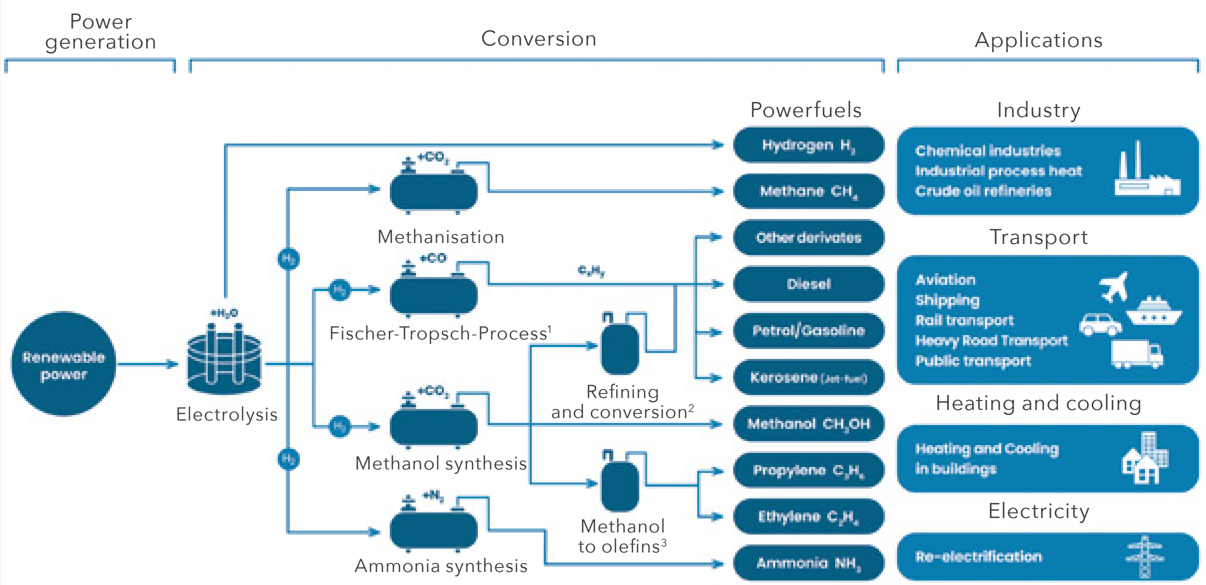
South Africa, therefore, is uniquely positioned to play a leading role in a global hydrogen economy, having both an excellent renewable-energy resource endowment and a highly developed local synthetic-fuel industry. A 10% market share in the potential future demand for green ammonia, sustainable aviation fuel and green steel has been estimated as requiring 25–30 million tonnes of green hydrogen as input, and an export potential of 160 billion euros (Bischof-Niemz, 2021).

Cape Town is home to two Hydrogen South Africa (HySA) institutes, namely HySA/Catalysis at the University of Cape Town and HySA Systems at the University of the Western Cape, both established by the Department of Science and Technology in 2007. Currently, the institutes focus on components and systems for fuel cells rather than hydrogen generation. Hydrogen generation, storage, transport and codes and standards fall under the mandate of

HySA Infrastructure, which is located at North-West University. In 2020, the Department of Science and Innovation, as it is now known, initiated a process to develop a roadmap that will steer South Africa towards a hydrogen economy. The aim of the roadmap is to put into perspective costs associated with rolling out green hydrogen technologies, as well as sourcing brown and blue hydrogen from existing facilities as part of the just transition phase.

The City's commitment to carbon neutrality will most likely require the local development of a hydrogen economy for the supply of sustainable aviation and shipping fuel, industrial heating applications, and for use in fuel cells to power heavy vehicles. The City's Climate Change Action Plan includes an action "developing a regional value chain for carbon-neutral molecular fuels", and an energy vision that sees the City and partners supporting a local green hydrogen pilot by 2025. As with all difficult energy and climate challenges, however, success will depend heavily on national, regional and local collaboration.

FIGURE 51: PRODUCTION PATHWAYS FOR GREEN HYDROGEN-DERIVED GREEN POWERFUELS



1. Includes: Fischer-Tropsch synthesis,hydrocracking, isomerisation and distillation.
2. Includes: ME/OME synthesis, olefin synthesis, oligomerisation and hydrotrating.
3. Methanol-to-olefins process.

Source: https://www.powerfuels.org/powerfuels

THE CARBON IMPACT OF WASTE

7.1 OVERVIEW

General waste sent to City-owned landfills has remained steady in the past four years, with an average annual disposal rate of 1,15 million tonnes. Landfilled organic waste is not only a contaminant of other, potentially recoverable materials in the waste system, but also a major source of methane emissions in Cape Town. Methane arising from both landfilled organic waste and wastewater treatment is a powerful GHG, which has historically seen the waste sector account for 10% of citywide GHG emissions. Solid waste contributes 94% and wastewater about 6% to the total combined emissions for the waste portion of the citywide GHG inventory. This proportion has been relatively consistent over time; however, if left unchecked, absolute emissions from the waste sector would grow in line with expected population growth rates. The City has already made some inroads in addressing emissions from this sector by investing in landfill gas capture and methane flaring at three landfills and one wastewater treatment works, with further augmentation of waste treatment facilities already in the pipeline. Aside from methane, the emissions embedded in discarded products are not currently estimated for Cape Town's inventory, but will nonetheless be significant, given the scale of materials sent to landfill. Therefore, the prevention and diversion of all types of waste with more circular production processes is essential to reduce Cape Town's GHG emissions.

While utilising landfill gas is an important step, the ultimate goal is to divert polluting or useful waste streams before they reach landfill. National and provincial targets in South Africa are extremely ambitious, requiring large-scale diversion of solid waste, particularly organic waste, from landfill in a very short timeframe shown in table 15.

Further targets have also been set for the integration of informal waste pickers with municipal recycling collection systems. Interventions to achieve diversion include separation at source through home composting and drop-off programmes, and solutions for low-income areas, such as residents swopping recyclables for token-purchased groceries. Pilots and/or roll-outs are under way in all these areas of work. Scaling up, however, is an immense challenge for a large and rapidly urbanising developing city in a poor economic climate, with limited scope for increased tariffs. Moreover, the integration of informal waste pickers requires a coordinated cross-cutting approach between a number of City departments and external stakeholders, which will take some time to coordinate and implement.

Since the private sector collects about 50% of waste, a new partnership model between the private and public sector is required to meet the diversion targets. A regulatory basis for this is now emerging through recent draft amendments to the National Environmental Management: Waste Act of 2008, which outlines regulations regarding extended producer responsibility (EPR). In terms of the draft amendments, EPR "means that a producer's responsibility for their product is extended to the post-consumer stage of a product's life cycle". For the time being, the draft amendments apply to the electrical and electronic equipment sector, the lighting sector, and the paper, packaging and some single-use product sectors. EPR aims to ensure that these sectors' products are either recycled or upcycled, and that waste products disposed of at landfill are kept to a minimum. This means that producers, or a class of producers, including brand owners, would be required to set up procedures and processes, and invest resources, to implement EPR measures with regard to the management of waste generated by their industries. This includes lightbulbs, batteries, solar panels, single-use products, vinyl, metal and glass packaging, vehicle lights, laser lighting, toys, television and computer screens, and a variety of domestic appliances (DEFF, 2021).

On the journey to carbon neutrality, all organic waste will need to be fully diverted from landfill, and single-use materials must be eliminated from the waste stream. The bulk of the remaining waste materials will need to be recovered and maximum value derived from Cape Town's waste stream through EPR and industrial symbiosis. Industrial symbiosis is a form of brokering to bring companies together in innovative collaborations, finding ways to use the waste from one as raw materials for another. The City is a funder of the Western Cape Industrial Symbiosis Programme (WISP),[20] a free facilitation service that connects businesses with unused or residual resources, such as materials, energy, water, assets, logistics and expertise. These measures are critical for creating a market for recovered materials, and will have multiple co-benefits in terms of job creation, the cleanliness of Cape Town, and reduced littering and illegal dumping (O'Carroll, et al., 2014). However, an accelerated waste transition faces certain key challenges, including:

- international/national and local economics, particularly the recent collapse of the international recycling market, and the lack of secondary industry and investments in Cape Town as downstream recipients of recyclables;
- rapid urbanisation and densification, particularly informality; and
- revenue and budgetary constraints on the costs of ongoing provision of efficient and cost-effective waste infrastructure and services.

Since 2006, supported by an Integrated Waste Management Policy and a by-law that Council approved in 2010, the City has been transitioning away from an outdated waste service delivery model based on the collection and landfilling of waste. Additional actions coordinated with other stakeholders – notably citizens, businesses, industry and both provincial and national governments – will be required to support this transition. The City will also need to be responsive to forces of supply and demand in the markets for useful waste products and recoverable waste materials. Citizens have a pivotal role to play in minimising their waste, reducing costs by refraining from illegal dumping, making waste-aware product choices, and recycling proactively. Advocacy is required to tackle the production and use of single-use and non-recyclable materials. The City already undertakes significant composting of garden waste, and there is potential to create solutions for the remaining organic waste in both the private sector and the City waste streams.

TABLE 15: HIGHLY AMBITIOUS NATIONAL AND PROVINCIAL WASTE DIVERSION TARGETS

National Waste Management Strategy 2020 waste diversion goal	2025 target	2030 target	2035 target
Prevent waste, and where waste cannot be prevented, ensure that the following targeted percentages of waste are diverted from landfill, leading to zero waste going to landfill in future.	40% of waste diverted from landfill	55% of waste diverted from landfill	>70% of waste diverted from landfill

Western Cape provincial organic waste diversion goal	2022 target	2027 target
Goal 3: Effective and efficient utilisation of resources Objective 3: Increase waste diversion through reuse, recovery and recycling	50% of organic waste diverted from landfill	100% of organic waste diverted from landfill

20 https://www.greencape.co.za/content/sector/wisp

7.2 PRIVATE WASTE-TO-ENERGY CASE STUDY

The Waste Transformers project, a pilot on-site waste-to-energy plant (see picture below), was in operation between November 2018 to August 2019 at the N1 City shopping mall in Cape Town. The mall has over 140 shops and restaurants, which made it an ideal location for implementing and testing the technology's feasibility.

The system extracted methane from an anaerobic bio-digester with organic waste as input, which was then used to fuel a generator that produced electricity. The 6 kVA generator powered approximately 10 of the shops and restaurants in the mall. Useful by-products produced included hot water used by various stores, and a liquid fertiliser (compost), which was distributed for landscaping across the developer's property portfolio and sold to balance the operating cost of the system. While the system was relatively small compared to the mall's demand, it was modular and required no external power to operate and used on-site waste, avoiding emissions from waste transportation (Africa Utility Week, 2019).

The pilot system was decommissioned after 11 months of operation as the commercial viability of the plant was dependent on the sale of compost produced by the plant, for which a market could not be established given the small quantity produced compared to the larger compost and fertiliser suppliers. Growthpoint Properties, who funded the pilot project, are currently developing a portfolio-wide approach to waste management which will support a range of initiatives intended to reduce waste to landfill at the appropriate scale, which may include on-site composting in future (Growthpoint Properties, 2021).

FIGURE 52: SMALL-SCALE WASTE TRANSFORMERS PROJECT AT N1 CITY SHOPPING MALL, CAPE TOWN

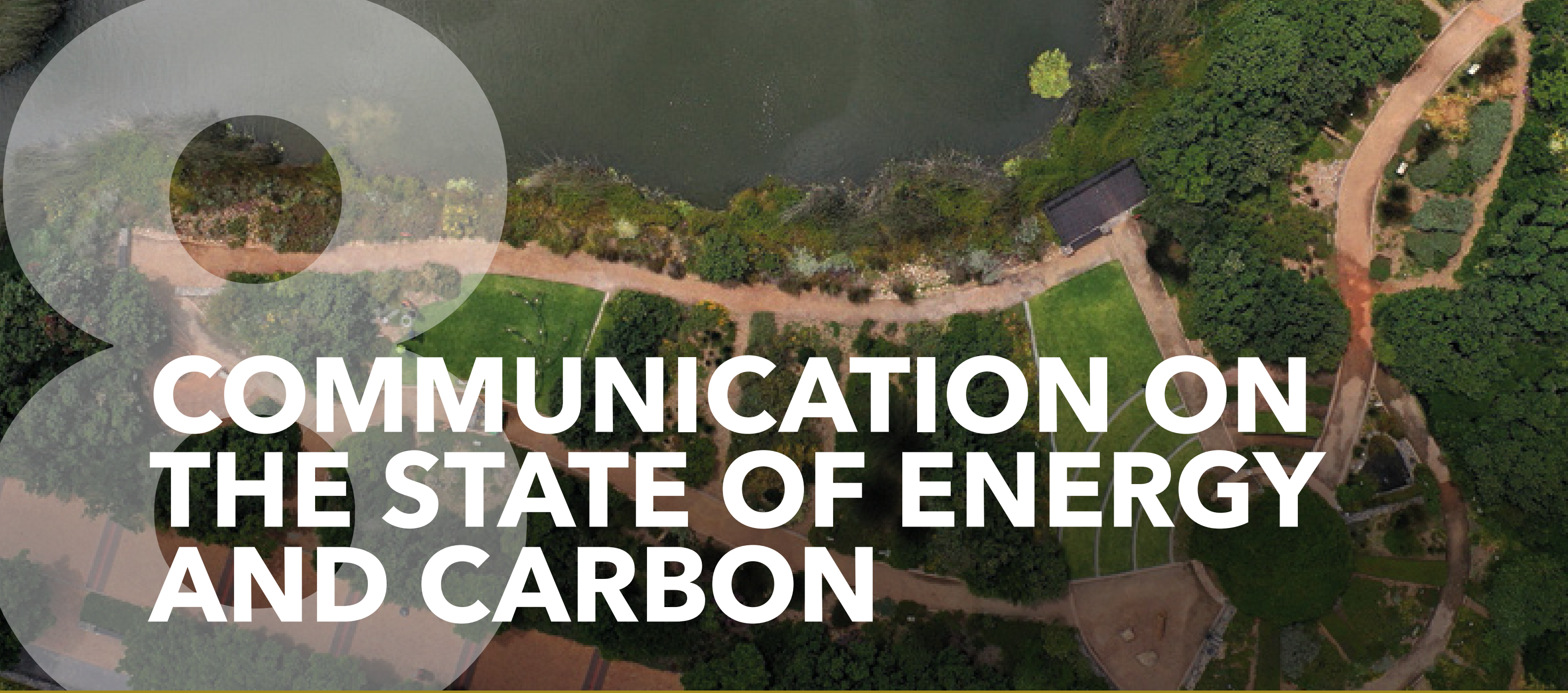
Source: Source: Growthpoint Properties.

7.3 CITY OF CAPE TOWN LANDFILL GAS EXTRACTION AND UTILISATION PROJECT

The eradication of landfill gas, which is a major contributor to global warming, would not only assist the City with green electricity generation, but also contribute to meeting local and national climate change mitigation commitments.

Waste-to-energy projects are part of the City's Integrated Waste Management Strategy and are being implemented under the landfill gas extraction and utilisation project. The biogas in landfills is combustible and can be captured and used as a fuel for heating, generating electricity or running vehicles. The City intends largely using it as an electricity-generating fuel and, in September 2014, registered a programme of activities in terms of the Clean Development Mechanism for landfill gas extraction and destruction at its landfill sites (UNFCCC, n.d.).

In phase 1, landfill gas extraction and flaring have been established at the Coastal Park and Bellville South landfills, and a similar system is being developed at Vissershok South landfill. The same will also be implemented at a future to-be-developed landfill. Coastal Park earned its first carbon credits under the Clean Development Mechanism in June 2021, having avoided 126 274 tonnes of CO_2-equivalent emissions for the first monitoring period between January 2018, when monitoring began, and July 2019. Phase 2 of the project includes the conversion of the landfill gas to electricity. To this end, 2 MW of gas engine generation capacity will be installed at Coastal Park in 2021/22, with units also being considered for Bellville South, as well as the Vissershok South and North landfill gas projects. This will offset more emissions by avoiding coal-fired electricity use, as well as reduce City electricity purchases, which would make up for installation costs.



8 COMMUNICATION ON THE STATE OF ENERGY AND CARBON

South Africa faces a range of energy challenges including load-shedding, the carbon intensity of the electricity grid, the technical opportunities and challenges of an increased uptake of distributed self-generation, and continued energy poverty despite a high level of electrification. In addition to technical solutions, addressing these problems requires collaboration between several role players who can influence decisions, reinforce systems, and engage residents, businesses and other organisations on best sustainability practices and behavioural change. Such a complex task calls for cross-cutting communication through various proactive and reactive platforms.

Historically, energy communication between a municipality and its customers has been about service provision. However, as energy supply and use has become more complex, and we engage more with our customers, it has become crucial to provide information that would enable customers to make sound energy decisions. At the same time, an energy future that is safe, clean and equitable will also require input and engagement from all Capetonians. For this reason, the City has launched a number of focused energy communications initiatives in recent years.

In 2008, for instance, when the country started experiencing severe load-shedding, primarily due to low plant availability, the City launched the Saving Electricity campaign to empower citizens. The campaign focused on educating customers on various ways to reduce their electricity consumption, thereby relieving pressure on the electricity grid and cutting their electricity bills in the face of rising tariffs. This included the promotion of renewable technologies such as solar water heaters (SWHs) and solar PV systems. In addition, the City established an accredited service providers programme for SWHs to help residents gain access to high-quality accredited installers.

Since 2015, Cape Town has experienced an exponential uptake in SSEG, specifically solar rooftop PV installations, many of which had not been authorised by the City's Electricity Department as required by law. The City supports the uptake of distributed renewable-energy systems, but it must be done in a safe and legal manner. The safety risk of unauthorised systems compromises the integrity of the grid. Therefore, in 2018, a PV registration campaign was launched to alert residents and businesses to the legal requirements, the safety risks, the City's registration process, as well as the consequences of non-compliance for their solar PV systems.

While often reactive to global and local events, climate change communication has also increased in recent years due to the need for urgent climate action, encouraging behavioural change in citizens and motivating them to reduce their carbon emissions. The need to boost our resilience and adapt to the effects of climate change, including rising temperatures, severe drought and rising sea levels, too requires ongoing engagement and customer education.

In this chapter, we highlight these and other communication interventions used to target both government and civil-society stakeholders, including City staff, other government and NGO partners, as well as external stakeholders, including the residential and commercial sectors.

8.1 GOVERNMENT AND CIVIL-SOCIETY STAKEHOLDERS

Communicating with, and raising awareness among, colleagues in the City, other tiers of government and NGO partners is an essential part of creating local sustainability champions and ensuring that all campaigns align to create a united voice.

8.1.1 PARTNERSHIPS

Electric vehicle task team – In 2018, the Energy Security Game Changer, a joint programme of the Western Cape government and the City, identified the creation of an enabling environment for the uptake of EVs as a special project. Globally, e-mobility is seen to be a major disruptor in both the energy and transport space, with projections indicating that all new mass-market vehicles will be electric by 2030. While the uptake may be slower in developing economies such as South Africa, it is critical for the region to be prepared by creating an enabling environment and identifying what economic and job opportunities can be harnessed in the province.

To this end, an EV task team was established, with the Energy Security Game Changer as secretariat. Apart from the provincial government and the City, other task team members included:

- Eskom (both national and regional);
- GreenCape;
- various original equipment manufacturers who had EVs available for sale;
- the Electric Vehicle Industry Association; and
- uYilo eMobility Technology Innovation Programme.

A subcommittee on charging infrastructure was also established to investigate what would be needed to ensure adequate charging infrastructure in the province. This subcommittee was made up of representatives from the Western Cape Government, City, Eskom, GreenCape and uYilo.

The EV task team was disbanded when the Energy Security Game Changer ended in 2020. Yet the need to continue engaging and working together remains, especially as EVs become more of a reality in South Africa, and the nature of the technology involves a diverse range of role players. As many of the issues relating to the uptake of e-mobility will occur at a local level, the City, with support from GreenCape, is investigating the re-establishment of the EV task team for 2021.

8.1.2 AWARENESS CAMPAIGNS

Climate change quiz – In October 2019, SEM facilitated a climate change quiz for City staff on the municipality's intranet. The aim was to conduct a mini-research project through a multiple-choice quiz to gain a better understanding of staff's knowledge of climate change, and to provide tips on how everyone can help reduce the impact of climate change. The quiz also aimed to sensitise staff to the danger of inaction: The longer we wait to make the necessary changes, the more difficult and expensive it will be to achieve our targets of carbon neutrality by 2050. Altogether 1 294 staff members completed the quiz.

The quiz also offered an opportunity for staff to submit ideas for how their department, branch or unit can help tackle climate change. Submissions ranged from having recycling bins in the office, to starting a climate change awareness campaign, and ensuring that projects are climate friendly. These suggestions are reflected in the City's Climate Change Action Plan and the climate change communications campaign launched in 2021.

City Transversal Education Forum – This forum is an internal initiative that takes a look at all City departments' awareness, education, training and communications interventions and identifies opportunities for collaboration. On the journey towards sustainable development, it is vital for the City's approach to education and communication to be cohesive, integrated and aligned.

The Transversal Education Forum focuses on:

- establishing a more holistic approach to the City's sustainability messaging;
- promoting a sense of public pride in Cape Town as a sustainable city among City employees and councillors, residents, businesses, schools, tertiary institutions, the media, tourists, sponsors, etc.;
- aligning initiatives with key City campaigns, and mainstreaming the sustainability messages in all City communications;
- compiling a programme or catalogue of awareness, education and training initiatives, and a calendar of events; and
- implementing joint initiatives as and when appropriate, working collaboratively on interventions, sharing information, workloads, resources and budget wherever possible, and gathering information for evaluation, monitoring and reporting of project performance and progress.

The forum is managed, coordinated and monitored by the Environmental Management Department. Meetings between the participating departments take place once a quarter, with each department represented by one or two staff members.

Climate Change Strategy and Action Plan stakeholder engagement – From late 2019 to mid-2021, the City engaged extensively with stakeholders regarding the development of its Climate Change Strategy and Action Plan, with the support of independent facilitators from the Western Cape Economic Development Partnership. These engagements included:

- key City departments and colleagues in the "transversal, policy and innovation" cluster;
- portfolio committees and other councillor bodies;
- civil-society groupings;
- stakeholders in the green economy; and
- statutory public participation on the Climate Change Strategy.

Workshops were designed to be interactive and poster-driven. However, after the onset of the Covid pandemic, these were redesigned for cyberspace, employing online 'storymaps' based on the posters.[21]

8.2 EXTERNAL STAKEHOLDERS

External stakeholders include Cape Town residents and businessowners, but also national and international parties who have an interest in how Cape Town is tackling the challenges of energy and climate change.

8.2.1 PARTNERSHIPS

Energy Water Waste Forum – The Energy Water Waste Forum for Cape Town's commercial sector is a partnership between the City, the Western Cape government, the South African Property Owners' Association (SAPOA) and a number of other partners. It was established in 2009 as the Energy Efficiency Forum. Following the drought in Cape Town, the scope of the forum was expanded to cover broader resource efficiency in the commercial sector, also including water and waste, hence its renaming in 2018. The forum is a platform for sharing resource-efficiency initiatives, policy and practical knowledge.

The forum's objective is to engage with owners and managers of offices, shopping centres, hotels and other commercial and public buildings, as well as businesses and consultants to provide practical knowledge and support to promote resource efficiency and waste minimisation. It also offers valuable networking opportunities. The forum has approximately 1 400 registered members, and participation is free.

Career expos and exhibitions – A partnership between several primary schools, high schools, tertiary institutions and internal City departments, the career exhibitions aim to raise awareness of available programmes and initiatives in the energy sector. The exhibitions take place towards the end of each school term to engage students and provide them with advice and resources that can help them make career decisions.

21 https://arcg.is/18WzCv0

8.2.2 AWARENESS CAMPAIGNS

Climate change communication – To achieve the ambitious target of being carbon neutral by 2050 and drive climate resilience at the same time requires all residents, businesses, organisations and government to play their part. Therefore, it is essential that clear communication galvanises support and:

- educates residents and key groups on the City's climate change response plans and activities;
- educates citizens, particularly the youth, on the role that individuals and groups can play in reducing carbon emissions, mitigating climate risk and being resilient to future climate crises; and
- emphasises the co-benefits of climate action by linking climate change messaging with the vision of a better future, namely an equitable, safe, healthy and fair future that offers opportunities in the green economy.

To initiate the development of the climate change communications campaign, the following preparatory work has been done:

- Stakeholder research on Capetonians' perceptions of climate change. This will help inform messaging, channels and messengers when designing campaign components.
- Development of a campaign name/tagline and identifier for a corporate-level climate change campaign. Under the banner of Let's ACT (see below), this will be launched in the course of 2021/22.

Low-income energy services communications campaign – Despite a very high (97,7%) degree of electrification in Cape Town, and the City's provision of an energy services social package to low-income households, the poor largely remain in a position of energy poverty. Unable to afford additional electricity once the monthly subsidy has been exhausted, they revert to using other, less desirable forms of energy, such as paraffin, candles and biomass (known as energy-stacking). Growing numbers of households are also either in the queue to receive a grid connection, which means they do not have access to electricity subsidies, or have settled in informal areas that will never be supplied with grid electricity because they are not suitable for development.

Various departments in the City, including EGD, Disaster Risk Management, Informal Settlements, Public Housing and Environmental Management, communicate with low-income communities on a range of issues. As there may be an overlap, it is important that messaging is clear and consistent.

SEM's LINES Unit is developing a communication strategy that can integrate with the work of other departments and:

- help households make better energy choices that will save them money, give them better energy access, and increase their resilience to future shocks and stresses, such as climate events; and
- provide tips to low-income households that will encourage the effective use of safe and modern energy sources, encourage safer and efficient energy practices, promote thermal insulation of dwellings, and discourage electricity theft and tampering.

Cape Town Future Energy Festival – This festival took the form of a series of fun, family-friendly virtual event experiences designed to include residents in Cape Town's future energy story. It aimed to spark conversations on climate action, energy efficiency, solar and wind power, water and waste efficiency, smart transport and sustainable living.

The festival kicked off with 'Watt's in the Pot?', an energy-efficient cooking competition that invited the public to share recipes using energy-efficient methods and appliances.

FIGURE 53: THE CITY OF CAPE TOWN'S LET'S ACT CLIMATE ACTION CAMPAIGN

Source: City of Cape Town.

The Smart City Kids series, in turn, is aimed at children aged 4–8 and introduces the concepts of energy, waste, water, transport and food to our future sustainability champions. These engaging and interactive shows are not only fun and entertaining, but also teach children how they can start helping to protect our environment for their future. Meanwhile, the Future Energy Conversations are meant for those who want to develop a deeper understanding of the challenges and opportunities around energy, climate change and sustainability. The series brings together thought leaders in industry and government to discuss the tough questions relating to these issues, and provides a platform to share inspiring case studies on the journey towards carbon neutrality by 2050.

The **My Clean Green Home** design competition, hosted in collaboration with the GBCSA, aimed to demonstrate sustainable living in action. The competition was targeted at built-environment students and professionals to showcase how efficient-design principles and sustainable materials can be used to build an NZC home. Team Mahali's winning design is a modular 'house in a box', covered by an overarching tree-like structure made from upcycled and locally available materials. The design, which incorporates rainwater harvesting, solar power generation, passive cooling and an edible food garden, has been on display at a few locations across town.

Winter energy-efficiency education – This annual social media campaign normally takes place from May to July to raise awareness of the need to save energy. Targeted at residents and businesses, it provides no-cost, low-cost and invest-to-save tips that citizens can adapt and practise daily. Some printed media (posters and brochures) are distributed to City buildings and, where possible, to schools as well.

Small-scale embedded generation registration campaign – In recent years, Cape Town has seen an increase in the number of SSEG systems, specifically rooftop solar PV. Yet many customers are connecting to the network illegally, without prior approval from the City. For this reason, an awareness campaign was launched in July 2018 and ran until June 2019 to educate customers about the need to register their systems, and the risks that unauthorised systems pose to the network. The registration process was communicated to citizens through social media, rates bill inserts, installer events and an online video. The City also extended its original registration deadline and created an online preregistration portal to make it easy for residents to initiate the process of registering their PV systems. The registration campaign proved very successful: Registrations grew from 400 before the campaign to over 1 400 thereafter, thereby more than tripling the number of applications received.

Electric vehicle promotion – Prior to the pandemic, the City started designing a communications campaign on e-mobility. However, all communication plans not directly related to curbing the pandemic were subsequently put on hold. Towards the end of 2020, the EV fleet pilot project and the solar-powered public EV charging stations necessitated appropriate communication. In response, a limited campaign was run about the need to support e-mobility, what the City is doing in this regard, and how it supports post-Covid climate action. The campaign included:

- the design and development of an identifier to use as part of campaign material;
- opinion pieces on news sites by the executive director of Energy and Climate Change, outlining the importance of e-mobility and the City's support and programme of action in this regard; and
- a soft launch attended by the Deputy Mayor, relevant councillors and key project stakeholders, a media release, as well as a video of the City's free solar-powered EV charging stations for public use.

A longer-term awareness campaign on e-mobility and EVs will be developed in 2021 in support of the broader climate change campaign that is currently being designed.

Solar water heater programme – This programme was launched in 2014 to support the uptake of SWHs in the mid to high-income residential sector in Cape Town, and to provide residents with information on this cost-effective, energy-efficient product that could save electricity and money. A project management unit was established for the SWH programme to serve as an intermediary between service providers and customers, screen service providers' applications for accreditation, and inspect installations to confirm adherence to the code of conduct for accredited service providers. The City also ran intensive promotion, education and advertising campaigns.

However, due to changes in technology, the market and regulations over the past two to three years, as well as the Cape Town drought, the focus has shifted away from a dedicated SWH programme to incorporate a spectrum of low-carbon technologies and interventions. The City is currently reviewing a suite of residential-focused interventions that will form part of a wider residential energy programme to be launched in 2021/22.

Electricity Generation and Distribution departmental communication – Through various education and awareness programmes, EGD provides information on electricity safety, discourages vandalism, and encourages residents to report faults and other incidents. Education on tariff structures, FBE and the associated subsidies is also provided. The main vehicles used for this purpose are school and clinic visits, community meetings, housing consumer education forums, electrification education and awareness sessions for new beneficiaries, holiday programmes in libraries and community halls, subcouncil meetings and mayoral roadshows. Various media and resources are used, such as DVDs, pamphlets and colouring books. Messaging is aimed at:

- discouraging electricity infrastructure tampering and vandalism, and copper and infrastructure theft;
- urging residents to report faults, electricity incidents and crime;
- providing information on electricity tariffs; and
- highlighting the dangers of electricity misuse.

8.3 PUBLICATIONS

Informative publications are essential for communicating substantive technical content to both internal and external stakeholders.

Small-Scale Embedded Generation Frequently Asked Questions and Registration Guidelines booklet – Developed in May 2019, this tool guides both customers and City employees through the SSEG registration process. The target audience is primarily administrative officers in EGD, and call centre agents. It helps City staff address residents' enquiries timeously and provide accurate information.

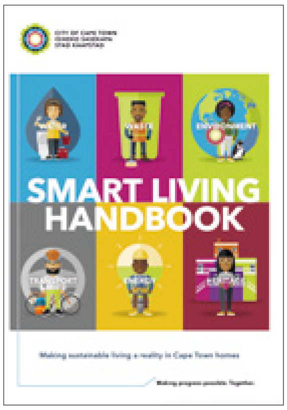
Scan the QR code to view online.

State of Energy – Like the previous three editions of 2003, 2009 and 2015, this fourth iteration of the Cape Town State of Energy report provides background information to guide the City's strategy development in relation to energy. The extensive data gathering for the report is also a means to monitor progress towards existing targets and support the redefinition of goals and targets going forward.

Smart Living Handbook – The Smart Living Handbook guides Capetonians to become more resilient and live more sustainable lives. It contains useful information and handy tips to help residents make the best choices to reduce their energy and water consumption and waste output. It also provides information on how to keep our natural world as strong and diverse as possible. The handbook is divided into six chapters addressing water, waste, environment, transport, energy and heritage respectively. Each chapter covers:

- the key challenge relating to the resource;
- what the City is doing to manage the resource;
- what residents can do in their homes to help conserve the resource; and
- contacts and information sources, and steps for implementation.

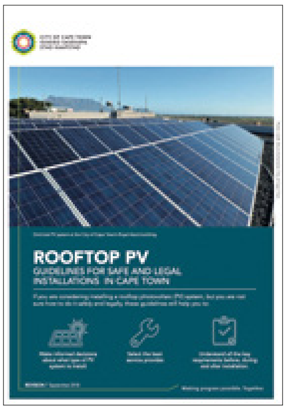
The Smart Living Handbook was recently named best once-off publication at the 2020 SA Publications Forum awards.



Scan the QR code to view online.

Rooftop photovoltaic: Guidelines for safe and legal installations in Cape Town – This booklet was developed particularly for residential customers who are considering installing a rooftop PV system, but do not know how to do so safely and legally. The guidelines help them make informed decisions on the type of PV systems to install, select the best service provider, and understand all the key requirements before, during and after installation.

The booklet outlines the safety implications for PV installations, and the four typical configurations for residential and commercial PV systems. It also features a checklist to ensure a quality installation service, including the different registration bodies, PV panel standards, approved inverters, compliance documents needed, and structural assessments that need to be carried out throughout the installation phases.



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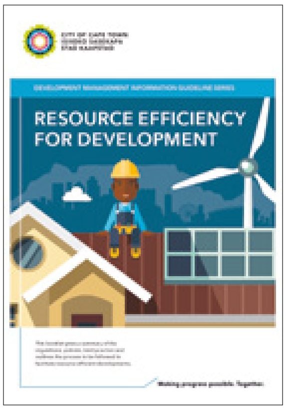
Resource Efficiency for Development book – The Resource Efficiency for Development book is an integral part of the City's Development Management Information guideline series. The book is a reference guide to various policies, legal directives and guidelines that form part of the City's overall sustainability framework relating to the built environment. It covers seven environmental resource-related areas, namely site selection, transport, water, energy, construction material, the natural environment and waste management. Regulations, policies, best practices and processes are colour coded according to how legally binding they are.



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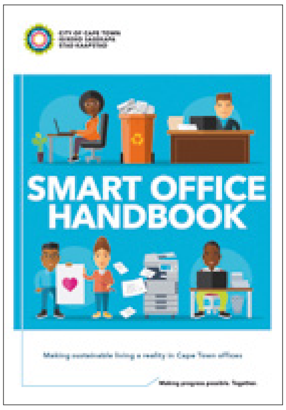
Smart Office Handbook – This guide to greening one's office space is not only a handbook, but a practical toolkit with various downloadable resources. The Smart Office Handbook was launched in 2013 and was updated and relaunch in 2021. The step-by-step toolkit has been designed to assist both internal City office managers and other Capetonians working in an office setting on their journey towards a greener office.

An entire Smart Office toolkit is available at www.capetown.gov.za/smartoffice. It includes the handbook along with a range of supporting resources and publications, such as posters and checklists.



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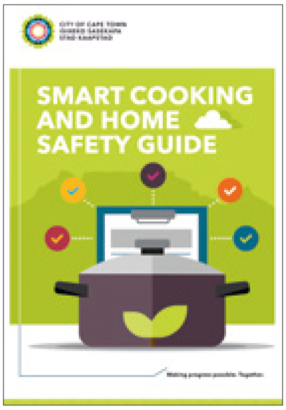
Smart Cooking and Home Safety Guide – This guide helps residents find more efficient ways of cooking and using energy in their homes. It was developed as part of the City's Smart Living campaign.



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8.4 OTHER COMMUNICATION TOOLS AND CHANNELS

Building Centre exhibition – The recently renovated exhibit hosted by the Sustainable Energy Markets Department at the Building Centre, is a call to action for all residents and highlights the City's new climate change action communication campaign, Let's ACT. For a stronger Cape Town. The exhibit specifically focuses on Cape Town's ambitious target for all new buildings to be net-zero carbon by 2030 and all existing buildings to be net-zero carbon by 2050. Buildings are key to the citywide goal of carbon neutrality by 2050. The exhibit is designed to intrigue architects, builders and home renovators and features different rooms of a home with technologies, design principals and behaviours required to meet net-zero carbon in operation.

The Building Centre is the largest permanent exhibition centre of its kind and open to the public seven days a week showcasing information, materials and technologies for architects, designers, building professionals and homeowners for their residential and commercial building and renovating projects. It is located at the Northgate business complex in Ysterplaat, some 10 km outside central Cape Town and hosts over 200 exhibitions of building materials and products for both residential and commercial projects.

Saving Electricity website – This communication platform assists residences and businesses with ways to reduce their energy consumption, and information about the City's drive to shrink Cape Town's carbon footprint and build a sustainable, resilient city. The website features top ways to save electricity, access to performance-monitored, accredited service providers, and documents on efficient energy and home greening.

It also provides a wealth of information on SWHs, solar PV systems and renewables, climate change and energy-efficient tips and resources.

For more, go to www.savingelectricity.org.za.

City of Cape Town website – The City's own website is the main platform for information on services and programmes, and for updates on the energy and carbon work the municipality is doing. It serves as the portal to lodge service complaints, register new connections and SSEG systems, and view load-shedding schedules and updates. To support the website, key information is also shared on various social media platforms, such as Twitter, Facebook, LinkedIn and YouTube.

8.5 CONCLUSION

The role of municipal energy and climate change communication has transitioned from the municipality being the service provider and customers mere passive users, to customers having more decision-making power in how they use energy and what technologies they choose. This evolution continues as more residents become small-scale generators, and the energy market opens up for people to become active participants, who can choose who they buy electricity from and/or sell it to. In Cape Town, almost half of our carbon emissions relate to electricity consumption in the residential and commercial sector. Therefore, the City's communication about energy choices is fundamentally also about climate action choices.

Delivering an internal and external communications framework that provides clear, consistent, informative and engaging messaging requires collaboration between traditional, digital and broadcast communication efforts. It also calls for stakeholder engagement initiatives with government, commercial businesses, residents, community leaders, academic institutions and NGOs.

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10 STATISTICAL ANNEXURES

10.1 ENERGY DATA OVERVIEW

TABLE A1: INDICATORS, CAPE TOWN, 2012–2018

Population	2012	2016	2017	2018
Cape Town population	3 890 505	4 246 670	4 333 921	4 423 834
Total number of households	1 068 573	1 166 910	1 200 396	1 234 317
Average household size	3,61	3,62	3,59	3,56
Population density (persons per km^2)	1 584	1 729	1 765	1 801
Economy and socioeconomic factors	**2012**	**2016**	**2017**	**2018**
Unemployment rates	24%	23%	-	23%
Human Development Index	0,74	0,75	-	0,74
Poverty (% households earning <R3 200/month in nominal ZAR)	47,93%	-	-	-
Cape Town gross value added (GVA) (constant 2016 ZAR millions)	357 141	387 758	392 049	396 319
Energy	**2012**	**2016**	**2017**	**2018**
Total energy consumption (GJ)	166 546 855	170 419 505	166 684 410	159 675 980
Total energy consumption, excluding international marine and aviation (GJ)	148 133 267	151 157 864	146 225 004	139 948 449
Energy consumption per capita, excluding international marine and aviation (GJ/capita)	38,08	35,59	33,74	31,64
Energy intensity, excluding international marine and aviation (GJ/GVA constant 2016 ZAR millions)	415	390	373	353
Energy intensity, excluding international marine and aviation (GVA constant 2016 ZAR/GJ)	2 411	2 565	2 681	2 832
Emissions	**2012**	**2016**	**2017**	**2018**
Total energy-related GHG emissions (tCO_2e)	21 411 912	20 747 641	19 727 930	19 932 984
Total energy-related GHG emissions (excluding international marine and aviation) (tCO_2e)	20 065 046	19 349 785	18 248 347	18 510 013
Total waste emissions (tCO_2e)	1 871 730	1 887 157	2 028 714	1 841 310
Emissions per capita (energy only, all fuels) (tCO_2e/capita)	5,50	4,89	4,55	4,51
Emissions per capita (energy only, excluding international marine and aviation) (tCO_2e/capita)	5,16	4,56	4,21	4,18
Emissions per capita (all energy and waste) (tCO_2e/capita)	5,98	5,33	5,02	4,92
Electricity	**2012**	**2016**	**2017**	**2018**
Electricity system maximum demand (MW)	1 919	1 898	1 773	1 742
Renewable energy (small-scale embedded generation, on-site or City-purchased, and renewable power purchased from IPPs) (kWh)	7 772 649	19 968 170	33 650 762	47 399 184
Renewable energy as share of total electricity demand (%)	0,001%	0,157%	0,274%	0,393%
Municipal facilities and operations	**2012**	**2016**	**2017**	**2018**
Energy (GJ)	2 113 380	2 043 711	2 027 339	2 017 361
Energy-related GHG emissions (tCO_2e)	452 601	410 004	391 615	411 477
Electricity (kWh)	424 252 670	396 135 228	391 675 256	379 809 530
Petrol and diesel (lit)	15 996 267	16 796 718	16 776 496	17 675 958

Waste	2012	2016	2017	2018
Waste generated (tonnes)	2 118 528	3 149 202	3 045 698	2 660 149
Waste minimised (%)	24%	55%	51%	45%
Waste per capita (kg/capita/day)	1,50	2,04	1,94	1,66
Household energy and energy poverty				
Solar water heater installations (SWHs)	**2012**	**2016**	**2017**	**2018**
High-pressure SWHs installed	25 000	49 500	52 986	62 500
Low-pressure SWHs installed	4 510			
Electrified households (lighting as proxy)	94%	98%	98%	98%
Households using 'clean and safe' fuels for cooking	95%	98%	98%	98%
Households receiving free basic electricity (FBE), City and Eskom distribution areas	384 962	364 718	337 086	306 419
Maximum possible share of indigent households accessing FBE (households receiving FBE ÷ households earning <R3 200/month in 2011 nominal ZAR)	75%	65%	59%	52%
Transport and mobility	**2012**	**2016**	**2017**	**2018**
Non-motorised transport (NMT) as portion of all work trips	16%	-	-	9%
Private-vehicle transport as portion of all work trips	42%	-	-	53%
Public-vehicle transport as portion of all motorised work trips	46%	-	-	47%
Share of households that own one or more cars (%)	46,00%	49,10%	50,86%	51,97%
Number of light passenger vehicles	794 796	891 305	921 307	916 307

TABLE A2: CAPE TOWN AS A SHARE OF NATIONAL OR PROVINCIAL (2018)

General	Province (%)	National (%)
Population	67%	8%
Economy	72%	10%
Energy	**57%**	**6%**
Electricity	54%	5%
Coal	3%	0%
Petrol	76%	11%
Diesel	72%	10%
Paraffin	84%	6%
LPG	54%	9%
Natural gas	-	-
Heavy furnace oil	86%	1%
Jet fuel	98%	23%
Aviation gas	33%	5%
Marine fuels	100%	3%
Biomass	-	0%

Sources (General): World Bank; Stats SA; Quantec; IHS Markit.
Sources (Energy): Department of Energy, Fuel sales volume; City of Cape Town, Electricity and Air Quality; Eskom; NERSA; ACSA; Stats SA; ERC and SEA.

TABLE A3: ENERGY BALANCE (NATIVE UNITS), CAPE TOWN (2018)

Energy source (native units)	Electricity (kWh)	Petrol (lit)	Diesel (lit)	Paraffin (lit)	LPG (lit)
Electricity: National transmission grid	12 018 894 179	-	-	-	-
Electricity: Independent power producers (CCT power purchase agreement)	4 847 821	-	-	-	-
Electricity: SSEG (sold to City)	2 886 016	-	-	-	-
Electricity: SSEG (used on-site)	39 665 348	-	-	-	-
Liquid fuel distributors	-	1 304 704 292	1 238 725 151	43 645 685	44 737 495
Coal distributors	-	-	-	-	-
Total supply	**12 066 293 363**	**1 304 704 292**	**1 238 725 151**	**43 645 685**	**44 737 495**
Total final consumption	**12 066 293 363**	**1 304 704 292**	**1 238 725 151**	**43 645 685**	**44 737 495**
Residential	3 801 838 222	-	-	18 392 709	32 221 151
Commerce and institutional	5 425 891 707	-	-	799 298	1 385 986
Manufacturing and construction	1 654 102 205	-	64 044 058	16 683 589	11 130 359
Agriculture	53 936 218	-	67 242 124	7 770 089	-
On-road transport	-	1 304 704 292	1 107 438 969	-	-
Rail	124 147 882	-	-	-	-
Waterborne transport	-	-	-	-	-
Aviation	-	-	-	-	-
Losses (City)	1 006 377 130	-	-	-	-

Sources: Department of Energy, Fuel sales volume; City of Cape Town, Electricity and Air Quality; Eskom; NERSA; ACSA; Stats SA; ERC and SEA.
Losses (City) represent the differences between electricity bought by the City (from Eskom, SSEG customers and IPPs) and that sold by the City.
Marine fuels include marine fuel/furnace oil and marine diesel. Coal includes small amounts of coke and anthracite.
SSEG = Small-scale embedded generation.

Heavy furnace oil (lit)	Coal (kg)	Jet fuel (lit)	Aviation gas (lit)	International marine (lit)	Biomass (kg)	Data source
-	-	-	-	-	-	CCT, Eskom
-	-	-	-	-	-	CCT
-	-	-	-	-	-	CCT
-	-	-	-	-	-	
4 936 781	-	548 000 000	577 138	22 954 976	-	DMRE
-	62 184 190	-	-	-	-	CCT
4 936 781	**62 184 190**	**548 000 000**	**577 138**	**22 954 976**	**9 859 404**	
4 936 781	**62 184 190**	**548 000 000**	**577 138**	**22 954 976**	**9 859 404**	
-	-	-	-	-	1 537 285	Stats SA, CCT, DMRE, Eskom
-	9 549 558	-	-	-	3 895 980	CCT, DMRE, Eskom
4 936 781	52 634 632	-	-	-	4 426 139	CCT, DMRE, Eskom
-	-	-	-	-	-	CCT, DMRE, Eskom
-	-	-	-	-	-	CCT, DMRE
-	-	-	-	-	-	Eskom
-	-	-	-	22 954 976	-	DMRE
-	-	548 000 000	577 138	-	-	CCT, DMRE, NERSA
-	-	-	-	-	-	CCT

TABLE A4: ENERGY BALANCE (ENERGY (GJ)), CAPE TOWN (2018)

Energy source (GJ)	Electricity	Petrol	Diesel	Paraffin	LPG
Electricity: National transmission grid	43 268 019	-	-	-	-
Electricity: Independent power producers (CCT power purchase agreement)	17 452	-	-	-	-
Electricity: SSEG (sold to City)	10 390	-	-	-	-
Electricity: SSEG (used on-site)	142 795	-	-	-	-
Liquid fuel distributors	-	44 620 887	47 195 428	1 614 890	1 194 491
Coal distributors	-	-	-	-	-
Total supply	**43 438 656**	**44 620 887**	**47 195 428**	**1 614 890**	**1 194 491**
Total final consumption	**43 438 656**	**44 620 887**	**47 195 428**	**1 614 890**	**1 194 491**
Residential	13 686 618	-	-	680 530	860 305
Commerce and institutional	19 533 210	-	-	29 574	37 006
Manufacturing and construction	5 954 768	-	2 440 079	617 293	297 181
Agriculture	194 170	-	2 561 925	287 493	-
On-road transport	-	44 620 887	42 193 425	-	-
Rail	446 932	-	-	-	-
Waterborne transport	-	-	-	-	-
Aviation	-	-	-	-	-
Losses (City)	3 622 958	-	-	-	-
Original unit	kWh	lit	lit	lit	lit

Sources: Department of Energy, Fuel sales volume; City of Cape Town, Electricity and Air Quality; Eskom; NERSA; ACSA; Stats SA; ERC and SEA. Losses (City) represent the differences between electricity bought by the City (from Eskom, SSEG customers and IPPs) and that sold by the City. Marine fuels include marine fuel oil and marine diesel. Coal includes small amounts of coke and anthracite.

Heavy furnace oil	Coal	Jet fuel	Aviation gas	Marine fuels	Biomass	Total
-	-	-	-	-	-	43 268 019
-	-	-	-	-	-	17 452
-	-	-	-	-	-	10 390
-	-	-	-	-	-	142 795
205 370	-	18 796 400	19 565	911 566	-	114 558 597
-	1 511 117	-	-	-	-	1 511 117
205 370	**1 511 117**	**18 796 400**	**19 565**	**911 566**	**167 610**	**159 675 980**
205 370	**1 511 117**	**18 796 400**	**19 565**	**911 566**	**167 610**	**159 675 980**
-	-	-	-	-	26 134	15 253 586
-	232 095	-	-	-	66 232	19 898 117
205 370	1 279 022	-	-	-	75 244	10 868 956
-	-	-	-	-	-	3 043 589
-	-	-	-	-	-	86 814 312
-	-	-	-	-	-	446 932
-	-	-	-	911 566	-	911 566
-	-	18 796 400	19 565	-	-	18 815 965
-	-	-	-	-	-	3 622 958
lit	kg	lit	lit	lit	kg	

TABLE A5: ENERGY CONSUMPTION BY SECTOR, SHOWING LOCAL GOVERNMENT SEPARATELY, TRANSPORT MODES AMALGAMATED (2012–2018)

Energy consumption by sector (GJ)	2012	2013	2014	2015	2016	2017	2018
Residential	17 574 927	17 114 272	16 699 486	16 628 213	16 576 847	15 751 567	15 253 586
Commercial	18 503 596	18 248 312	18 191 141	17 973 338	18 397 771	17 989 528	17 880 756
Local government	2 113 380	2 090 472	2 044 022	2 004 651	2 043 711	2 027 339	2 017 361
Industrial	16 392 075	16 704 576	16 962 121	16 755 158	13 275 122	12 176 725	10 868 956
Agriculture	3 381 274	4 053 634	5 196 770	6 295 837	7 431 108	6 636 926	3 043 589
Transport	104 766 458	98 309 406	102 900 599	106 329 396	108 763 864	108 355 044	106 988 774
Losses	3 815 144	3 766 120	4 232 219	4 344 263	3 931 082	3 747 282	3 622 958
Total (including aviation and marine)	**166 546 855**	**160 286 792**	**166 226 359**	**170 330 855**	**170 419 505**	**166 684 410**	**159 675 980**
Total (excluding aviation and marine)	**148 133 267**	**143 448 232**	**150 014 243**	**152 166 424**	**151 157 864**	**146 225 004**	**139 948 449**
Oil refining	-	-	-	-	-	-	9 490 065

TABLE A6: ENERGY CONSUMPTION BY SECTOR (GJ)

	Residential	Commercial	Local government	Industrial[1]	Agriculture	Transport	Losses	Total
2007	22 976 123	38 293 538		1 276 451		65 099 015		**127 645 127**
2012	17 574 927	18 503 596	16 392 075	2 113 380	3 381 274	104 766 458	3 815 144	**166 546 855**
2018	15 253 586	17 880 756	10 868 956	2 017 361	3 043 589	106 988 774	3 622 958	**159 675 980**
% change 2007 to 2012	-23,51%	-8,87%		65,57%		60,93%		**30,48%**
% change 2012 to 2018	-13,21%	-3,37%	-33,69%	-4,54%	-9,99%	2,12%	-5,04%	**-4,13%**

[1]Data quality is poor, so uncertainties are high. However, the drop between 2012 and 2018 may reflect a small number of heating energy-intensive firms closing.

TABLE A7: ENERGY CONSUMPTION AND CARBON EMISSIONS CHANGE BY ENERGY SOURCE

Energy source	GJ			tCO_2e		
	2012	2018	Growth p.a.	2012	2018	Growth p.a.
Electricity	47 495 500	43 438 656	-1,5%	12 747 959	11 527 623	-1,7%
Petrol	48 082 523	44 620 887	-1,2%	3 353 227	3 111 816	-1,2%
Diesel	42 075 844	47 195 428	1,9%	3 136 291	3 517 900	1,9%
LPG	2 437 103	1 194 491	-11,2%	154 187	75 571	-11,2%
Paraffin	2 172 466	1 614 890	-4,8%	157 154	116 820	-4,8%
Fuel oil	1 634 089	205 370	-29,2%	127 196	15 986	-29,2%
Aviation gasoline	30 371	19 565	-7,1%	2 139	1 378	-7,1%
Jet fuel	14 474 600	18 796 400	4,5%	1 041 288	1 352 194	4,5%
International marine	3 908 618	911 566	-21,5%	303 439	69 398	-21,8%
Coal	4 080 046	1 511 117	-15,3%	388 737	143 979	-15,3%
Wood	155 697	167 610	1,2%	296	318	1,2%
Total	**166 546 855**	**159 675 980**	**-0,7%**	**21 411 912**	**19 932 984**	**-1,2%**

TABLE A8: ENERGY DEMAND BY ENERGY SOURCE AND SECTOR (2018)

Energy demand (GJ)	Electricity	Petrol	Diesel	LPG	Paraffin	Fuel oil
Residential	13 686 618	-	-	860 305	680 530	-
Commercial and institutional	19 533 210	-	-	37 006	29 574	-
Manufacturing and construction	5 954 768	-	2 440 079	297 181	617 293	205 370
Agriculture, forestry and fishing	194 170	-	2 561 925	-	287 493	-
Non-specified	3 622 958	-	-	-	-	-
On-road transport	-	44 620 887	42 193 425	-	-	-
Rail	446 932	-	-	-	-	-
Waterborne navigation	-	-	-	-	-	-
Aviation	-	-	-	-	-	-
Off-road transport	-	-	-	-	-	-
Subtotal	**43 438 656**	**44 620 887**	**47 195 428**	**1 194 491**	**1 614 890**	**205 370**
Oil refining	-	-	56 477	7 144 542	-	2 289 046
Total	**43 438 656**	**44 620 887**	**47 251 905**	**8 339 033**	**1 614 890**	**2 494 416**
Percentage	27,20%	27,94%	29,56%	0,75%	1,01%	0,13%

Sources: Department of Energy, Fuel sales volume; City of Cape Town, Electricity and Air Quality; Eskom; NERSA; ACSA; Stats SA; ERC and SEA; SAPIA.

Coal category includes coal, coke and anthracite. Marine fuels include marine diesel and marine fuel oil. Non-specified category includes municipal electricity losses. Oil refining: New to the State of Energy, and not included in any indicators so that these are comparable to previous years. Hydrocarbon consumption of the refinery in energy terms has been estimated from the estimated scope 1 emissions (SAPIA and oil industry annual reports), and a fuel mix has been estimated from other public sources, adjusted to match emissions. Therefore, these data have been inferred indirectly from the available public data, and were not published by Astron refinery.

Aviation gasoline	Jet fuel	Marine fuels	Coal	Wood	Total	Percentage
-	-	-	-	26 134	**15 253 586**	9,55%
-	-	-	232 095	66 232	**19 898 117**	12,46%
-	-	-	1 279 022	75 244	**10 868 956**	6,81%
-	-	-	-	-	**3 043 589**	1,91%
-	-	-	-	-	**3 622 958**	2,27%
-	-	-	-	-	**86 814 312**	54,37%
-	-	-	-	-	**446 932**	0,28%
-	-	911 566	-	-	**911 566**	0,57%
19 565	18 796 400	-	-	-	**18 815 965**	11,78%
-	-	-	-	-	**-**	0,00%
19 565	**18 796 400**	**911 566**	**1 511 117**	**167 610**	**159 675 980**	**100,00%**
-	-	-	-	-	**9 490 065**	5,94%
19 565	**18 796 400**	**911 566**	**1 511 117**	**167 610**	**169 166 045**	**100%**
0,01%	11,77%	0,57%	0,95%	0,10%	**100,00%**	

TABLE A9: EMISSIONS BY ENERGY SOURCE AND SECTOR (2018)

Emissions (tCO_2e)	Electricity	Petrol	Diesel	LPG	Paraffin	Fuel oil
Residential	3 640 463	-	-	54 428	49 229	-
Commercial and institutional	5 169 131	-	-	2 341	2 139	-
Manufacturing and construction	1 582 765	-	181 881	18 802	44 654	15 986
Agriculture, forestry and fishing	51 732	-	190 963	-	20 797	-
Non-specified	964 458	-	-	-	-	-
On-road transport	-	3 111 816	3 145 056	-	-	-
Rail	119 074	-	-	-	-	-
Waterborne navigation	-	-	-	-	-	-
Aviation	-	-	-	-	-	-
Off-road transport	-	-	-	-	-	-
Solid waste	-	-	-	-	-	-
Wastewater	-	-	-	-	-	-
Subtotal	**11 527 623**	**3 111 816**	**3 517 900**	**75 571**	**116 820**	**15 986**
Oil refining[1]	-	-	4 210	498 253	-	178 177
Total	**11 527 623**	**3 111 816**	**3 522 110**	**573 824**	**116 820**	**194 163**
Percentage	52,94%	14,29%	16,16%	0,35%	0,54%	0,07%

Sources: Department of Energy, Fuel sales volume; City of Cape Town, Electricity and Air Quality; Eskom; NERSA; ACSA; Stats SA; ERC and SEA; SAPIA; GPC/IPCC.

Coal category includes coal, coke and anthracite. Marine fuels include marine diesel and marine fuel oil.

Non-specified category includes municipal electricity losses.

Note: Emissions exclude scope 3 electricity emissions (in buildings and rail), but includes scope 3 aviation and waterborne navigation emissions.

[1] LPG - refinery gas

Aviation gasoline	Jet fuel	Marine fuels	Coal	Wood	Total	Percentage
-	-	-	-	50	**3 744 170**	17,20%
-	-	-	22 117	126	**5 195 855**	23,86%
-	-	-	121 862	143	**1 966 093**	9,03%
-	-	-	-	-	**263 492**	1,21%
-	-	-	-	-	**964 458**	4,43%
-	-	-	-	-	**6 256 872**	28,74%
-	-	-	-	-	**119 074**	0,55%
-	-	69 398	-	-	**69 398**	0,32%
1 378	1 352 194	-	-	-	**1 353 572**	6,22%
-	-	-	-	-	**-**	0,00%
-	-	-	-	-	**1 721 214**	7,91%
-	-	-	-	-	**119 109**	0,55%
1 378	**1 352 194**	**69 398**	**143 979**	**318**	**21 773 306**	**100%**
-	-	-	-	-	**680 640**	3,03%
1 378	**1 352 194**	**69 398**	**143 979**	**318**	**22 453 946**	**100%**
0,01%	6,21%	0,32%	0,66%	0,001%	**100,00%**	

TABLE A10: ENERGY CONSUMPTION FOR CAPE TOWN, WESTERN CAPE AND SOUTH AFRICA (2018)

Fuel	Cape Town			Western Cape		
	Native unit	GJ	tCO_2e	Native unit	GJ	tCO_2e
Electricity	12 066 293 363	43 438 656	11 527 623	22 302 000 000	80 287 200	21 390 463
Coal	62 184 190	1 511 117	143 979	2 352 865 903	57 174 641	5 447 457
Petrol	1 304 704 292	44 620 887	3 111 816	1 725 264 449	59 004 044	4 114 883
Diesel	1 238 725 151	47 195 428	3 517 900	1 720 396 214	65 547 096	4 885 815
Paraffin	43 645 685	1 614 890	116 820	52 074 406	1 926 753	139 379
LPG	44 737 495	1 194 491	75 571	83 162 562	2 220 440	140 479
Natural gas	-	-	-	-	-	-
Heavy furnace oil	4 936 781	205 370	15 986	5 755 829	239 442	18 638
Jet fuel	548 000 000	18 796 400	1 352 194	559 647 612	19 195 913	1 380 935
Aviation gas	577 138	19 565	1 378	1 755 311	59 505	4 191
Marine fuels	22 954 976	911 566	69 398	22 954 976	911 566	69 398
Biomass	9 859 404	167 610	318	-	-	-
Total	**-**	**159 675 980**	**19 932 984**	**-**	**286 566 601**	**37 591 639**

Sources: Department of Energy, Fuel sales volume; City of Cape Town, Electricity and Air Quality; Eskom; NERSA; ACSA; Stats SA; ERC and SEA.

Excludes fuel used in power plants.

Jet fuel use in Cape Town is higher than in Western Cape, since Western Cape data are based on fuel sales data (not representative, as sales sometimes captured at wholesale level in neighbouring province, i.e. region of sale does not always equate to region of use, which means some areas are over or underreported); while Cape Town data are based on actual reported amount used at Cape Town International Airport, as reported to NERSA.

Coal category includes coke and anthracite.

Marine fuels include marine diesel and marine fuel oil.

Electricity includes municipal losses.

National			Native unit
Native unit	GJ	tCO_2e	
231 805 000 000	834 498 000	222 330 570	kWh
18 871 949 051	458 588 362	43 693 153	kg
11 750 425 545	401 864 554	28 025 632	lit
12 941 311 331	493 063 962	36 752 495	lit
739 110 907	27 347 104	1 978 262	lit
513 830 012	13 719 261	867 970	lit
2 136 036 348	87 577 490	4 927 679	m^3
571 839 253	23 788 513	1 851 674	lit
2 425 115 870	83 181 474	5 983 992	lit
10 664 916	361 541	25 467	lit
641 555 046	26 355 937	2 039 566	lit
25 085 572 610	426 454 734	810 264	kg
-	**2 876 800 931**	**349 286 723**	

TABLE A11: ENERGY INTENSITY OF GROSS DOMESTIC PRODUCT (GDP) AT CONSTANT PURCHASING POWER PARITIES (KOE/$15P)

	2019
Ukraine	0,232
Russia	0,210
Venezuela	0,205
Taiwan	0,189
South Africa	0,180
Iran	0,179
Kazakhstan	0,176
Canada	0,171
Uzbekistan	0,152
Nigeria	0,148
Cape Town[1]	0,16

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koe – kilo of oil equivalent (10–3 toe)

[1]*Calculated using State of Energy data*

10.2 ENERGY POLICY AND CITY ENGAGEMENT

TABLE A12: SUMMARY OF MOST PERTINENT REGULATIONS AND POLICY INSTRUMENTS AFFECTING LOCAL GOVERNMENT ELECTRICITY PROCUREMENT

Name	Type	Description
National Energy Regulator of South Africa (NERSA)	Licence requirement	All generators, distributors and traders of electricity in South Africa require a NERSA-issued licence
Electricity Regulation Act (ERA)	Act	Limits the choice of procurement in terms of quantity and type of generation to the minister of Energy
Integrated Resource Plan (IRP)	National policy document	Stipulates technology choice limitations that need to be adhered to
Preferential Procurement Financial Management Act (PPFMA)	Act	Stipulates minimum procurement requirements with regard to black economic empowerment and local content
Municipal Financial Management Act (MFMA)	Act	Governs procurement of goods and services by municipalities

TABLE A13: KEY NATIONAL LEGISLATION AND POLICIES RELATING TO CITY ENERGY DEVELOPMENT

Legislation/policy	Objectives	Key points
White Paper on Energy Policy, 1998	• Increase access to affordable energy services. • Improve energy governance. • Stimulate economic development. • Manage energy-related environmental and health effects. • Secure supply through diversity.	• Foundation of national energy policy. • Focus on energy poverty alleviation, which has resulted in widespread electrification and subsidised electricity for the poor. • Diversification of supply to ensure energy security, which lays the foundation for alternative generation technologies, including renewable energy.
White Paper on Renewable Energy, 2004	• Promote and implement renewable energy in South Africa.	• Focus on government support to achieve renewable energy targets. • Does not specifically look to support embedded generation, which remains somewhat of a policy vacuum.
National Energy Act (34 of 2008)	• Mandates the Department of Energy to ensure that diverse energy resources are available in sustainable quantities and at affordable prices to support economic growth and poverty alleviation, while also taking into account environmental considerations.	• Strong focus on diversifying supply. • Strong focus on increasing renewable energy generation.
National Energy Efficiency Strategy post-2015	• Aims to increase energy efficiency while considering the current economic and development context in South Africa.	• Builds on achievements of the National Energy-Efficiency Strategy 2005, stimulating further energy-efficiency improvements through a combination of fiscal and financial incentives, a legal and regulatory framework, and enabling measures.
Integrated Energy Plan, 2016	• Identifies eight policy objectives derived from the White Paper/Energy Act, looking to meeting these under various scenarios.	• The eight policy objectives of the draft Integrated Energy Plan strongly mirror local government roles and mandates.

<table>
<tr><td>Integrated Resource Plan (IRP) 2019</td><td rowspan="4">The IRP 2019 determines National Government’s plans for electricity capacity expansion up to 2030 based on its analysis of the ‘least-cost’ plan.
It addresses key assumptions that have changed since the IRP promulgation in 2011, including electricity demand projection, Eskom’s existing plant performance and technology costs.
Provides a governance framework for the industry.
Aims to increase the role of nuclear energy as part of the process of diversifying South Africa’s primary energy sources to ensure energy security.</td><td>Encourages a diversified energy mix with great emphasis placed on renewable-energy sources, particularly wind and solar.
Coal remains the largest energy supply, accounting for approximately 60% of total energy supply by 2030.</td></tr>
<tr><td>National Nuclear Regulator Act, 1999</td><td rowspan="3">Nuclear energy is promoted as an important part of a diversified energy mix.</td></tr>
<tr><td>Nuclear Energy Act, 1999</td></tr>
<tr><td>Nuclear Energy Policy and Strategy, 2008</td></tr>
<tr><td>Petroleum Products Act, 1977</td><td>This act provides measures for the efficient and effective distribution of petroleum products and price control.</td><td>The most recent amendment in 2005 sets out to delete a condition regarding the purchase and sale of certain petroleum products; to adjust the provision dealing with the system for the allocation of certain licences, and to extend the powers of the Minister of Minerals and Energy to make regulations.</td></tr>
<tr><td>Electricity Regulation Act, 2006</td><td>The act establishes a national framework for the electricity supply industry, from generation to distribution.
It makes provision for energy-efficiency measures to be promulgated, and ensures that incentives and penalties are legislated.</td><td>Allows for budget to be allocated for energy efficiency specifically.
Strong focus on municipalities for implementation.</td></tr>
<tr><td>NERSA Standard Conditions for Small-Scale Embedded Generation, 2011</td><td>This policy document makes provision for small-scale embedded energy generation.</td><td>Small-scale embedded generation may take place and will largely be the responsibility of local distributors to approve, monitor and regulate.
Related standards are being developed to guide this.</td></tr>
<tr><td>White Paper on National Climate Change Response, 2011</td><td>Presents the country’s vision for an effective climate change response and the long-term transition to a climate-resilient low-carbon economy and society.
The document identifies energy-efficiency measures, demand-side management and moving to a less emissions-intensive generation mix as the main interventions/opportunities for mitigation.</td><td>The policy specifically identifies a role for local government in implementation, and identifies the South African Local Government Association (SALGA) as a key support institution.</td></tr>
<tr><td>National GHG Reporting Regulations, 2017 (under the National Environmental Management: Air Quality Act, 2004)</td><td>Introduces a single national reporting system for the transparent reporting of greenhouse gas emissions, to assist South Africa to update and maintain a national greenhouse gas inventory and meet Paris Agreement targets.</td><td>The emissions data submitted in accordance with the GHG reporting regulations will facilitate SARS's determination of the associated tax liability of a taxpayer as defined under the Carbon Tax Act 15 of 2019.</td></tr>
<tr><td>Carbon Tax Act 15 of 2019 (amended in 2019)</td><td>Emitters are liable to pay a carbon tax in order to reduce overall GHG emissions and encourage behaviour change.</td><td>A carbon tax of R120/tCO_2e has been imposed on emitters exceeding the threshold, with a number of tax relief allowances that will reduce the initial tax rate during the first phase of implementation.
The carbon tax will be implemented through a phased approach. The first phase will take place from 1 June 2019 to 31 December 2022, and the second phase from 2023 to 2030.</td></tr>
</table>

Carbon Offset Regulations, 2019	• Outline the criteria that would render a project eligible under the South African carbon tax/offset system.	• All small-scale renewable-energy projects up to 15 MW contracted and installed capacity respectively for both REIPPPP (from bid window 3, i.e. signed on or before 9 May 2013) and non-REIPPPP projects are eligible as carbon offsets to provide an incentive for the uptake of such projects. • For projects greater than 15 MW, REIPPPP projects from the third bidding window and non-REIPPPP projects, except for technologies with a cost less than R1,09/ kWh, will be eligible as carbon offsets.
Low-Emission Development Strategy 2050, 2020	• An extension of NDC to ultimately become zero carbon by 2050 as per article 4 of Paris Agreement.	Rolled out in three stages: • Starting right (to be completed prior to end of 2021 financial year) • Turning the corner (to begin in parallel with the starting right stage and continue to 2025) • Massive roll-out (2025 to 2050)
SANS 204 and the National Building Regulations Part XA, 'Energy Efficiency', 2011	• This document provides for the amendment of the National Building Regulations to include energy-efficiency standards in all residential and commercial buildings. Importantly, it includes water heating, where at least 50% of heating needs must be met by non-electrical resistance means. • The amendment has made provision for a building envelope, fenestration, passive solar heating and insulation.	• Except under exceptional circumstances, solar water heating is now a requirement for all new buildings. • A government circular of December 2013 has extended the amended regulations to apply to all government-delivered low-income housing.
Green Transport Strategy (2018–2050)	• Reduce the negative impacts of transport on the environment, while addressing current and future transport demands.	• Promote green mobility to ensure that the transport sector supports the achievement of green economic growth targets. • A key focus on road transport to effect a significant reduction in emissions.

TABLE A14: KEY NATIONAL LEGISLATION AND POLICIES RELATING TO CITY WASTE DEVELOPMENT

Legislation/policy	Objectives	Key points
National Environmental Management Act (107 of 1998)	• Aims to avoid pollution and degradation of the environment, and to anticipate and prevent the negative impacts on the environment and on people's health.	• Underpinned by polluter-pays principle, cradle-to-grave, precautionary principle, and waste minimisation and avoidance.
White Paper on Integrated Pollution and Waste Management, 2000	• Manages the impact of pollution and waste on the receiving environment, and remediating damaged environments.	• A comprehensive approach to prevent pollution and minimise at source.
Air Quality Act (39 of 2004)	• Aims to protect the environment by developing measures that prevent air pollution and degradation, while promoting conservation and sustainable development through justifiable economic and social development.	• Provides norms and standards regulating airuality monitoring, management and control by all organs of state.

National Environmental Management: Waste Act (NEMWA) (59 of 2008) – National Environmental Management: Waste Amendment Act (NEMWAA) (26 of 2014)	• Avoid and minimise waste generation. • Reduce, reuse and recycle waste. • Encourage and ensure effective delivery of waste. • All listed waste management activities are to be licensed through an EIA process.	• Municipalities are required to develop Integrated Waste Management Plans to plan and manage waste properly. • In 2014, NEMWAA took effect to address the shortcomings of NEMWA. This included a detailed definition of waste and a precise end of waste status through opening up more opportunities for the recycling market.
National Waste Information Regulations, 2012	• Regulate the collection of data and information on waste management to ensure efficient planning for waste management activities.	• Waste generators are required to report on waste quantities generated, diverted and treated. While reporting, some requirements must be adhered to. These include name of facility, waste types and quantities generated, including percentage of waste diverted.
National Organic Waste Composting Strategy and Guidelines, 2013	• Aim to ensure that organic waste is diverted from landfill and used for composting.	• Reduce disposal to landfill, and subsequently prolong the lifespan of landfills, while minimising pollution and health hazards.
Waste Classification and Management Regulations, 2013	• Replace the minimum requirements for the handling, classification and disposal of hazardous waste. • Provide for the classification of waste by waste generators in accordance with SANS 1023:2008, within 180 days of generation.	• The Globally Harmonised System of Classification and Labelling of Chemicals classifies waste according to physical and health hazards, as well as hazards to the aquatic environment.
Norms and Standards for the Assessment of Waste to Landfill Disposal, 2013	• Stipulate the requirements for the assessment of waste before it reaches landfill.	• Waste is divided into four categories based on its total concentration and leachable concentration compared to acceptable limits.
Norms and Standards of Waste to Landfill, 2013	• Provide new classification of landfill sites, and requirements for containment and barrier design.	• The standard prescribes the type of waste to be disposed of at different classes of landfill sites. Certain types of waste such as tyres, asbestos, etc. are prohibited from disposal.
Norms and Standards for Extraction, Flaring or Recovery of Landfill Gas, 2013	• Aim to control the extraction, flaring or recovery of landfill gas at facilities in order to prevent or reduce potential adverse impacts on the biophysical and socioeconomic environments.	• Facilities are required to comply with these standards without a need to conduct a basic assessment and obtain a waste management licence.
National Waste Management Strategy, 2020	• Gives effect to NEMWA, while also addressing the legacy of inadequate waste services.	Outlines three overarching goals that all spheres of government and affected persons need to achieve. **Goal 1** Prevent waste, and where waste cannot be prevented, divert. **Goal 2** All South Africans live in clean communities, with waste services that are well managed and financially sustainable. **Goal 3** Mainstreaming of waste awareness and a culture of compliance, resulting in zero tolerance of pollution, litter and illegal dumping.

TABLE A15: OVERARCHING CITY OF CAPE TOWN POLICIES, STRATEGIES, PLANS AND BY-LAWS

Policy/strategy/plan/by-law	Purpose/objective/summary
Five-year Integrated Development Plan 2017–2022	The Integrated Development Plan (IDP) is the overall strategy document that guides all planning, executive decision making and municipal budgets. It sets out the development priorities of the City for a five-year period. The principles and objectives of the City's IDP 2017–2022 incorporate a major focus on building a sustainable, climate-resilient, resource-efficient and secure city. Sustainability and resilience are both guiding principles of the IDP. Priority 4 of the IDP is resource efficiency and security. Under this objective (1.4), the City is working to achieve an appropriate balance between economic development and the preservation of the natural environment, optimising natural assets, securing resources and creating a resource-efficient economy.
Municipal Spatial Development Framework (MSDF)	The MSDF sets out the spatial vision and development priorities to achieve a reconfigured, inclusive spatial form for Cape Town. It guides public and private investment decisions that will affect Cape Town's future spatial structure, and identifies areas where development is desirable and/or areas where urban development is discouraged.
Climate Change Policy (2017)	The vision of the Climate Change Policy is for Cape Town to become a city that is climate resilient, resource efficient and lower carbon, in order to enable sustainable and inclusive economic and social development, and environmental sustainability. To be superseded by a Paris Agreement-compliant Climate Strategy and Action Plan in 2021.
Resilience Strategy	The strategy offers a roadmap for a 21st-century metropolis that aims to strengthen the city against sudden potential shocks in the future, from storms and heatwaves, to cyberattacks, global financial crises and other unforeseen challenges. Includes a number of energy and climate actions.
Energy2040	The Energy2040 goal models a more resilient, lower-carbon, resource-efficient and equitable future for Cape Town. It informs the sustainable energy action plan into the future and sets targets for reducing carbon emissions and promoting efficient and sustainable use of energy. To be superseded by a Paris Agreement-compliant Climate Strategy and Action Plan in 2021.
Air Quality Management Plan for the City of Cape Town	The Air Quality Management Plan (aligned with the Western Cape Air Quality Management Plan) focuses on the need to reduce and minimise air pollution (and CO_2 emissions) and improve the health of the city's citizens.
Public Environmental Awareness, Education and Training Strategy	The Environmental Education, Awareness and Training Strategy promotes the education and empowerment of Cape Town's residents.
City of Cape Town Urban Design Policy	The Urban Design Policy supports sustainable city design and planning. Objective 8 of the policy states that "development should protect, value and enhance the natural environment through sustainable design", thus taking into account the ecological and environmental footprint, and accounting for and adapting to the changes in the environment brought about by climate change and other natural factors.
Cape Town Densification Policy	The Densification Policy aims to improve Cape Town's sustainability and enhance the quality of the built environment. It is believed that densification will lower resource use and travel time, thereby minimising the ecological, environmental and carbon footprint of the built environment.
Transit Oriented Development (TOD) Strategic Framework	To identify tools and mechanisms to be employed by various role players who have a collective impact on development, to ensure that they move progressively towards a more sustainable, compact and equitable urban form.

City of Cape Town Air Quality Management By-law	The Air Quality Management By law highlights the need to ensure that air pollution levels (and CO_2 emissions) are controlled and reduced as far as reasonably possible.
City of Cape Town Municipal Planning By-law	The criteria for decision making, such as considering the effects of land and development on other developments, and provincial/national legislation (section 99(2)), which may include the effect on the surrounding community, economic impact, and environmental health and safety.
City of Cape Town Integrated Waste Management and Amendment By-law	The Integrated Waste Management By-law (and its amendment) promotes the environmentally sustainable management of waste in Cape Town, thus mitigating the adverse effects that waste can have on climate change and environmental health.
Integrated Waste Management Policy	To guide the implementation of the waste hierarchy, with a specific focus on waste minimisation. The reduction in the amount of waste disposed at landfill sites will subsequently result in the reduction of GHG emitted, particularly methane from landfill sites.
Integrated Waste Management Plan	To give effect to the strategies for waste minimisation and the sustainable provision of waste services to minimise social, health, environmental and economic impacts.
Environmental Strategy (2017)	The City of Cape Town Environmental Strategy recognises the risks posed by climate change and natural hazards, and therefore commits the City to the following principle: "In taking decisions, implementing service delivery, operating, as well as planning for the future, the City will ensure a focus on resilience, enabling the city to withstand and mitigate the negative impacts of environmental hazards, proactively reduce Cape Town's vulnerability, and protect the city's economy."
Electricity Supply Amendment By-law (2017)	Amended regulations between service providers and customers.

TABLE A16: OVERVIEW OF NATIONAL BUILDING REGULATORY FRAMEWORK

Policy/regulation/strategy	Purpose/objective
National Building Regulations and Building Standards Act, 1977	This is principal legislation that governs all building and construction work in South Africa. The Building Regulations are divided into 23 chapters as follows: Part A: General principles and requirements, Part B: Structural design, Part C: Dimensions, Part D: Public safety, Part E: Demolition work, Part F: Site operations, Part G: Excavations, Part H: Foundations, Part J: Floors, Part K: Walls, Part L: Roofs, Part M: Stairways, Part N: Glazing, Part O: Lighting and ventilation, Part P: Drainage, Part Q: Non-water-borne sanitary disposal, Part R: Stormwater disposal, Part S: Facilities for disabled persons, Part T: Fire protection, Part U: Refuse disposal, Part V: Space heating, Part W: Fire installation, and parts X and XA: Energy usage
South African National Standard SANS 10400-XA, Energy efficiency in buildings	The National Building Regulations, and specifically the SANS 10400-XA (2011), regulates energy efficiency of buildings in South Africa. It provides for mandatory energy-efficiency interventions for all new buildings and appropriate extensions and renovation. These regulations have been in place since 2013 and are currently being updated with new energy-use intensity requirements. The recently published draft updated SANS 10400-XA Version 2 (2020) regulations introduce more stringent energy-efficiency requirements.

Municipal Systems Act, 2000 (32 of 2000)	The Municipal Systems Act directs municipalities to provide sustainable services to their communities, and promotes increased community involvement in the provision of energy services. Section 23 requires municipalities to produce integrated development plans for the medium-term development of their municipal areas to meet the needs of their communities.
Spatial Planning and Land Use Management Act, 2013 (16 of 2013)	The Spatial Planning and Land Use Management Act (SPLUMA) provides for inclusive, equitable and efficient spatial planning and land-use management. SPLUMA sets out a number of climate change-related development principles: spatial justice, spatial sustainability and spatial resilience.
Taxation Laws Amendment Act (25 of 2015), amendment of section 12B of Act 58 of 1962	This introduced a tax break for investments in renewable energy, incentivising small-scale embedded generation such as rooftop solar photovoltaic systems. It provides an accelerated depreciation allowance on renewable energy to 100% in one year.
Taxation Laws Amendment Act (25 of 2015), amendment of section 12L of Act 58 of 1962	This introduced a higher-level tax break for investments in energy-efficiency projects. The deduction claim for substantiated energy-efficiency savings was raised to 95c per kilowatt hour.
SANS 204	Energy efficiency in buildings with artificial or natural environmental control.
SANS 941: Energy efficiency of electrical and electronic apparatus	Covers the energy-efficiency requirements, measurements, methods and appropriate labelling of energy efficiency on electrical and electronic apparatus. Implications are for both manufacturers and importers.
SANS 151: Fixed electrical storage water heaters	Prescribes methods for durability, safety and performance of electrically fitted hot water storage tanks. The standard currently contains a section that prescribes minimum standard heat loss for different geysers. The minimum requirement for electrical geysers will be raised to that of the current solar heater requirements.
SANS 1544: Energy performance certificates for buildings	This specifies the methodology for calculating energy performance in existing buildings, and is mandatory for all buildings meeting certain criteria by 2022. Regulations for the mandatory display and submission of energy performance certificates for buildings.
SANS 10106: Installation of solar water systems	This revised standard updates the requirements for installation of domestic solar water heaters.
SANS 50010: Measurement and verification of local content	Specifies the methodology for calculating energy savings. This tool is required for projects submitted on the 12L energy-efficiency tax rebate programme.
SATS 1286: Local goods, services and works measurement and verification of local contents	Relevant upon application for the designation of solar water heaters.
VC 9006: Compulsory specification for hot water storage tanks for domestic use	All domestic hot water cylinders imported, manufactured, sold or installed in South Africa must now adhere to the SANS 5151 standard and cross-referenced substandards.
SANS 1307	Domestic solar water heaters.

TABLE A17: ENGAGING STAKEHOLDERS IN THE ENERGY REALM

Date	Title	Description	URL
Brochures and booklets			
Jun-15	"Top ways to help you save electricity" twofold brochure	This brochure highlights the different no-cost, low-cost and invest-to-save options that residents can adopt to save and use energy efficiently in their households.	
Nov-15	Cape Town Energy2040	Fold-up booklet that outlines Cape Town's pathway towards a more resilient, low-carbon and resource-efficient future. It includes Cape Town's energy profile, energy consumption by sector, energy supply and demand, as well as carbon emissions.	https://savingelectricity.org.za/wp-content/uploads/2018/01/2040_energy_vision_cct_brochure.pdf
Posters and pamphlets			
Jun-15	"Top ways to save electricity" posters (A0, A1, A3) in all three languages	Each poster provides tips on how residents can practise smart energy-usage habits.	
Jun-15	A household checklist pamphlet to assist households to save energy	This is a checklist pamphlet that can be used as a reference guide for people to be able to monitor their energy usage habits pertaining to appliances, cooking, laundry, hot water and lighting in the home.	https://savingelectricity.org.za/wp-content/uploads/2018/01/household_guide.pdf
Jul-18	Rooftop PV guidelines for safe and legal installations in Cape Town	To make citizens aware of the importance of registering their solar PV systems, including the compliance schedules and safety implications.	https://savingelectricity.org.za/wp-content/uploads/2018/09/4255-FA-CCT-Energy-PV-Brochure_September2018.pdf
Nov-19	Resource Efficiency Criteria for Development in Cape Town	Resource Efficiency Criteria for Development in Cape Town is a reference guide to a large number of policies, legal directives and guidelines that form part of the City's overall sustainability framework relating to the built environment.	https://savingelectricity.org.za/wp-content/uploads/2018/01/resource_efficiency_criteria_for_development_2016.pdf
Sep-20	The City of Cape Town's Carbon Neutral 2050 Commitment	This briefly outlines the City's vision for a carbon-neutral Cape Town by 2050 and provides guidance on what businesses, residents and the municipality can do.	http://resource.capetown.gov.za/documentcentre/Documents/City%20strategies,%20plans%20and%20frameworks/Carbon_Neutral_2050_Commitment.pdf
Videos			
Feb-19	"Register SSEG system" animated video	This is an animated video on the SSEG registration process. It informs residents on the registration process, the safety implications, and the consequences of non-compliance, which may include electricity supply disconnection or an additional service fee charge.	https://www.youtube.com/watch?v=mnh6ewoxEzo&feature=emb_logo&ab_channel=CityofCapeTown

May 2020 – January 2021	Cape Town Future Energy Festival videos	As part of the festival, two education video series were run: • Energy Conversations: Meant for those who want to develop a deeper understanding of the challenges and opportunities around energy, climate change and sustainability. The series brings together thought leaders in industry and government to discuss the tough questions relating to these issues, and provides a platform for inspiring case studies on the journey to carbon neutrality by 2050. • Smart City Kids: Nine episodes for children between the ages of 4 and 8 to introduce them to concepts of energy, water, waste, transport, food and protecting our environment.	https://www.youtube.com/channel/UCykOp8Sd268_C7-B3LI-94A/featured
Dec-20	Driving change for all: Cape Town's first free public EV charger launched	This video outlines the City's support for e-mobility and the installation of its first solar-powered EV charging station, donated by UNIDO.	https://www.youtube.com/watch?v=wlkj86aoHow&ab_channel=CityofCapeTown

10.3 SMALL-SCALE EMBEDDED GENERATION AND CITY ENERGY PLANTS

TABLE A18: POTENTIAL LOCATIONS AND SIZE OF CITY-OWNED SOLAR PHOTOVOLTAIC EMBEDDED GENERATION DEVELOPMENT

Photovoltaic (PV) site name	PV system size (kW peak)	PV estimated annual generation (kWh)	PV installation type (rooftop or ground mounted)	PV site type
Kraaifontein wastewater treatment plant	<1 000	1 752 000	Ground-mounted	Wastewater treatment plant
Athlone wastewater treatment plant	2 400	4 204 800	Ground-mounted	Wastewater treatment plant
Bellville wastewater treatment plant	2 600	4 555 200	Ground-mounted	Wastewater treatment plant
Cape Flats wastewater treatment plant	3 400	5 956 800	Ground-mounted	Wastewater treatment plant
Mitchells Plain wastewater treatment works	1 800	3 153 600	Ground-mounted	Wastewater treatment plant
Potsdam wastewater treatment plant	2 800	4 905 600	Ground-mounted	Wastewater treatment plant
Wesfleur wastewater treatment plant	800	1 401 600	Ground-mounted	Wastewater treatment plant
Ndabeni Electricity depot	750	1 314 000	Rooftop	Electricity depot/facility
Athlone power station	50	87 600	Rooftop	Electricity depot/facility
Atlantis depot	40	70 080	Rooftop	Electricity depot/facility
Gugulethu Electricity depot	<100	175 200	Rooftop	Electricity depot/facility
Newlands network centre	100	175 200	Rooftop	Electricity depot/facility
Spyker Street depot (Helderberg)	80	140 160	Rooftop	Electricity depot/facility
Goodwood Transport Management Centre	<1 000	1 752 000	Rooftop	Transport Management Centre

Note: This is additional to larger scale embedded solar photovoltaic plans shown in table 8 and waste-to-energy projects shown in table 9.

TABLE A19: RENEWABLE-ENERGY PROJECTS IN DEVELOPMENT IN OTHER DIRECTORATES

Department	Technology	Total capacity (MW)
Wastewater	Biogas	10
Solid Waste[1]	Landfill gas	7

[1] 1,5 MW to be commissioned by end 2020.

TABLE A20: ELECTRICITY GENERATION BY CITY-OWNED POWER PLANTS

Electricity generated (kWh)	2011	2012	2013	2014	2015	2016	2017	2018	2019
Athlone	190 710	520 540	256 780	183 163	646 667	179 407	4 661	158 170	305 148
Roggebaai	35 510	201 870	78 950	989 820	586 160	108 960	6 400	157 040	346 720
Steenbras	82 095 152	126 319 294	122 863 838	141 127 643	112 958 640	50 036 337	22 680 690	69 519 761	80 784 800
Net energy sent out (kWh)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Athlone	71 360	411 460	148 190	84 675	551 739	83 054	-83 683	146 774	293 610
Roggebaai	-62 49	82 200	-25 850	931 590	573 218	92 891	-8 459	153 713	343 515
Steenbras	-20 977 171	-23 316 531	-30 222 600	-42 329 115	-27 406 200	5 702 400	703 600	16 067 900	3 408 000

Source: City of Cape Town.
Energy sent out may be lower than energy generated due to on-site use of electricity, in particular where the plant is not running, but still needs electricity to operate the facilities. Steenbras pumped storage acts as a battery to store Eskom electricity, and generally uses more electricity (when pumping water to the upper dam) than it produces, aside from the drought years, when water was transferred from another catchment to the top-level dam of the Steenbras system.

TABLE A21: MICRO-HYDROELECTRICITY GENERATION PLANTS OWNED BY THE CITY OF CAPE TOWN (2018)

Location	Type	Total turbine capacity (kW)	Electricity generated per annum (kWh)
Wemmershoek water treatment plant	2 x Francis	260	1 138 800
Blackheath water treatment plant	1 x Turgo	700	3 066 000
Faure water treatment plant	1 x Turgo	1 475	6 460 500
Steenbras water treatment plant	2 x Turgo	340	1 489 200
Total		2 775	12 154 500

Source: Cape Town State of Energy 2015.
Plants not metered (City plans to meter in future). Electricity generated per annum assumes a capacity factor of 50%.
http://www.usu.edu/ipe/wp-content/uploads/2015/11/Reliability-Hydro-Condensed.pdf

10.4 ECONOMIC INDICATORS

TABLE A22: CAPE TOWN, WESTERN CAPE AND SOUTH AFRICAN POPULATION AND GROWTH IN GROSS VALUE ADD (GVA) OVER TIME

Population	2001	2007	2012	2018	2001-2007	2007-2011	2011-2018
Cape Town	3 024 367	3 443 624	3 890 505	4 423 834	2,19%	2,47%	2,16%
Western Cape	4 465 873	5 113 877	5 916 674	6 621 326	2,28%	2,96%	1,89%
South Africa	45 571 274	49 119 759	52 834 005	57 779 622	1,26%	1,47%	1,50%
GVA (constant 2016 ZAR '000)							
Cape Town	234 517 288	313 932 104	357 141 078	396 319 174	4,98%	2,61%	1,75%
Western Cape	328 874 131	445 830 639	500 269 739	549 712 369	5,20%	2,33%	1,58%
South Africa	2 545 141 612	3 293 631 446	3 641 677 466	3 955 720 096	4,39%	2,03%	1,39%

Sources: World Bank, Stats SA, Quantec, IHS Markit.

TABLE A23: CAPE TOWN GROSS VALUE ADD DETAIL (CONSTANT 2016 ZAR)

GVA shares (%)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Agriculture	0,94	0,91	0,91	0,92	0,94	0,98	0,96	0,91	1,00	0,92	0,83
Mining	0,17	0,16	0,17	0,16	0,16	0,17	0,17	0,17	0,16	0,15	0,15
Manufacturing	15,30	15,79	15,69	15,59	15,37	15,05	14,74	14,69	14,44	14,34	14,07
Electricity	2,07	2,04	1,96	1,81	1,60	1,34	1,29	1,22	1,45	1,52	1,44
Construction	3,78	3,70	3,65	3,66	3,75	3,81	3,85	3,86	3,79	3,68	3,54
Trade	15,82	15,99	16,17	16,37	16,37	16,35	16,47	16,58	16,28	16,15	16,07
Transport	11,28	11,19	11,11	11,03	11,02	11,17	11,09	11,07	11,06	11,10	10,99
Finance	33,84	33,47	33,49	33,56	33,66	33,86	34,32	34,49	34,89	35,24	35,88
Community services	16,81	16,75	16,85	16,90	17,14	17,28	17,11	17,02	16,94	16,89	17,04
Total GVA	100	100	100	100	100	100	100	100	100	100	100

Source: IHS Markit, Regional eXplorer.

10.5 ELECTRICITY AND CITY OPERATIONS

TABLE A24: CITY OF CAPE TOWN ELECTRICITY SALES AND LOSSES

	Purchases (kWh)				Losses (kWh)	
	Eskom	SSEG	IPPs	Sales	Purchases less sales	Eskom-only purchases less sales
2008	10 634 836 477	-	4 704 335	9 792 661 093	846 879 719	842 175 384
2009	10 544 602 049	-	4 358 124	9 611 541 639	937 418 534	933 060 410
2010	10 561 089 998	-	7 065 226	9 694 710 999	873 444 225	866 378 999
2011	10 504 837 382	-	7 074 953	9 432 647 691	1 079 264 644	1 072 189 692
2012	10 447 735 022	-	7 772 649	9 395 745 320	1 059 762 351	1 051 989 702
2013	10 233 367 848	-	3 641 930	9 190 865 409	1 046 144 369	1 042 502 440
2014	10 222 890 521	5 784	5 126 906	9 052 406 779	1 175 616 432	1 170 489 526
2015	10 096 098 385	145 566	8 067 823	8 897 572 114	1 206 739 660	1 198 671 836
2016	10 066 683 719	782 312	6 596 829	8 982 095 656	1 091 967 203	1 085 370 374
2017	9 735 797 681	1 888 542	6 644 143	8 703 418 823	1 040 911 544	1 034 267 400
2018	9 524 820 324	2 886 016	4 847 821	8 526 177 031	1 006 377 130	1 001 529 309

Source: City of Cape Town.
Electricity sales exclude the impact of negative sales (i.e. purchases) from SSEG customers (where the City buys electricity from SSEG customers through the SSEG tariff).

TABLE A26: CHANGE IN ELECTRICITY SALES AND CUSTOMERS OVER TIME

Change in electricity sales and customers over time	Customers			
	2012	2018	Change (no.)	Change (%)
Lifeline	292 598	184 785	-107 813	-36,85%
Domestic	254 613	394 202	139 589	54,82%
Small power user and off-peak	28 182	27 817	-365	-1,30%
Large power user	1 373	1 248	-125	-9,10%
Total consumer sales	**576 766**	**608 052**	**31 286**	**5,42%**

Source: City of Cape Town.

TABLE A25: CITY OF CAPE TOWN ELECTRICITY PURCHASES FROM ESKOM BY TRANSMISSION AREA

kWh	Cape Town	Tygerberg	Blaauwberg	Oostenberg	Helderberg	Total
2008	6 496 331 848	2 450 593 149	506 607 542	648 400 124	532 903 814	10 634 836 477
2009	6 464 984 262	2 454 342 210	443 440 192	649 634 906	532 200 479	10 544 602 049
2010	6 479 289 382	2 452 233 206	445 002 083	649 055 342	535 509 985	10 561 089 998
2011	6 424 982 517	2 472 839 356	461 335 374	613 368 851	532 311 285	10 504 837 382
2012	6 419 285 365	2 414 535 040	469 051 195	618 314 547	526 548 875	10 447 735 022
2013	6 346 046 995	2 315 092 720	426 235 820	616 988 319	529 003 994	10 233 367 848
2014	6 290 944 903	2 420 166 850	477 474 793	503 619 033	530 684 941	10 222 890 521
2015	6 199 172 022	2 390 232 544	480 012 349	495 315 003	531 366 467	10 096 098 385
2016	6 176 356 432	2 409 271 310	458 281 108	480 616 870	542 157 999	10 066 683 719
2017	5 965 007 871	2 349 692 659	441 768 001	455 203 902	524 125 248	9 735 797 681
2018	5 798 380 457	2 305 784 581	451 757 319	456 400 196	512 497 770	9 524 820 324

Source: City of Cape Town.

kWh				kWh/customer			
2012	2018	Change (no.)	Change (%)	2012	2018	Change (no.)	Change (%)
1 022 902 225	530 419 827	-492 482 398	-48,15%	3 496	2 870	-625	-17,89%
2 437 815 559	2 297 749 629	-140 065 930	-5,75%	9 575	5 829	-3 746	-39,12%
1 690 723 214	1 694 690 476	3 967 261	0,23%	59 993	60 923	930	1,55%
3 859 334 287	3 648 555 118	-210 779 169	-5,46%	2 810 877	2 923 522	112 645	4,01%
9 010 775 285	**8 171 415 050**	**-839 360 235**	**-9,32%**	**15 623**	**13 439**	**-2 184**	**-13,98%**

TABLE A27: SHARE OF HOUSEHOLDS USING ELECTRICITY FOR LIGHTING (INDICATIVE OF ELECTRIFICATION) (2018)

	Buffalo City	Cape Town	Ekurhuleni	eThekwini	Johannesburg	Mangaung	Nelson Mandela Bay	Tshwane
All households	91%	98%	91%	98%	96%	98%	98%	92%
Formal households	98%	100%	99%	98%	100%	99%	99%	98%
Informal households	68%	91%	63%	95%	85%	88%	78%	63%

General Household Survey sample sizes at metro scale are not statistically significant.

TABLE A28: CITY OF CAPE TOWN BUILDINGS ELECTRICITY CONSUMPTION, 2015–2018

Building type (kWhs)	2015	2016	2017	2018
Corporate buildings (Facilities Management Department)	41 097 882	38 342 837	36 488 692	35 883 511
Recreational facilities	18 434 367	19 980 176	21 610 961	22 563 939
Electricity Services facilities	7 675 077	7 721 079	7 456 948	7 338 509
Transport facilities	4 594 942	4 464 965	6 756 564	8 025 873
Strategic assets	5 948 268	6 421 117	6 547 713	6 334 928
Clinics	3 405 486	4 043 252	5 410 937	5 058 505
Libraries	4 717 088	4 856 285	4 328 627	4 353 234
City Parks – depots	2 643 571	2 717 080	3 953 625	3 766 142
City Parks – cemeteries	269 940	183 693	173 503	215 076
Environmental Management (nature reserves and BSG)	348 175	217 852	218 094	211 123
Property management/other buildings	761 167	665 475	633 374	558 842
Early childhood development centres	569 672	569 672	569 672	569 672
Supply Chain Management store	144 125	149 226	154 813	151 704
Water and Sanitation facilities	587 954	416 714	1 944 338	1 364 541
Total electricity for municipal buildings	**91 197 716**	**90 749 424**	**96 247 861**	**96 395 598**

TABLE A29: COST OF LOCAL GOVERNMENT ENERGY CONSUMPTION (2018)

Energy source	Fuel unit	Fuel amount	Price/unit (real 2016 ZAR)	Cost (real 2016 ZAR)
Petrol	lit	6 001 850	13,41	80 471 655
Diesel	lit	11 674 108	12,47	145 536 216
Electricity	kWh	379 809 530	1,23	466 401 840

Sources: City of Cape Town (fuel amounts and electricity price), National Department of Energy (petrol and diesel price), Stats SA (CPI used to convert cost into real 2016 ZAR).

Electricity price represents that used by the City to estimate electricity savings in City operations. Prices for adjoining financial years were averaged to obtain a calendar-year value.

TABLE A30: LOCAL GOVERNMENT VEHICLE FLEET PETROL AND DIESEL CONSUMPTION

Liquid fuels consumption by City operations (lit)	2012	2013	2014	2015	2016	2017	2018
Petrol	5 996 777	6 030 878	5 786 945	5 765 165	5 725 735	5 609 297	6 001 850
Diesel	9 999 489	10 628 177	10 888 511	11 135 261	11 070 983	11 167 199	11 674 108
Total	**15 996 267**	**16 659 055**	**16 675 456**	**16 900 425**	**16 796 718**	**16 776 496**	**17 675 958**
Energy cost (real 2016 ZAR)	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Petrol	83 612 116	88 902 836	86 049 455	72 966 339	69 219 359	69 638 879	80 471 655
Diesel	132 958 691	148 981 504	152 185 184	126 015 885	114 947 714	124 262 369	145 536 216
Total	**216 570 807**	**237 884 340**	**238 234 639**	**198 982 224**	**184 167 073**	**193 901 248**	**226 007 871**

Source: City of Cape Town, Fleet Management Department.

TABLE A31: CITY OF CAPE TOWN FLEET BY CLASSIFICATION, 2018 AND 2019

	2018	2019
Bus medium	33	41
Minibus	206	217
Light delivery vehicle	2 088	2 319
Motorcycle	110	112
Mobile clinic	2	-
Panel van	541	609
Car	2 016	2 320
Truck	1 236	1 350
Truck specialised	309	322
Truck tanker	39	51
Plant heavy equipment	89	96
Plant light equipment	646	664
Other	1 392	1 107
Total	**8 707**	**9 208**

Source: City of Cape Town, Fleet Management Department.

TABLE A32: LOCAL GOVERNMENT ENERGY CONSUMPTION, EMISSIONS BY SOURCE/SERVICE (2018)

	Native (kWh)	tCO_2e	GJ
Wastewater	131 339 754	125 876	472 823
Buildings	96 395 598	92 385	347 024
Streetlights	81 315 157	77 932	292 735
Pump stations	54 056 140	51 807	194 602
Bulk water	15 020 619	14 396	54 074
Traffic lights	1 682 262	1 612	6 056
Vehicle fleet (petrol)[1]	6 001 850	14 315	205 263
Vehicle fleet (diesel)[1]	11 674 108	33 154	444 783
Total	-	**411 477**	**2 017 361**

[1] *In litres*
Source: City of Cape Town.

TABLE A33: LOCAL GOVERNMENT ENERGY CONSUMPTION, EMISSIONS AND ENERGY COSTS OVER TIME (2012–2018)

Energy consumption (GJ)	2012	2013	2014	2015	2016	2017	2018
Electricity	**1 527 310**	**1 479 283**	**1 431 256**	**1 383 229**	**1 426 087**	**1 410 031**	**1 367 314**
Wastewater	452 761	457 515	462 269	467 023	520 320	485 274	472 823
Buildings	486 414	433 713	381 012	328 312	326 698	346 492	347 024
Streetlights	353 649	353 649	353 649	353 649	345 296	297 922	292 735
Pump stations	159 935	159 935	159 935	159 935	159 935	202 876	194 602
Bulk water	68 543	68 543	68 543	68 543	68 543	72 140	54 074
Traffic lights	6 008	5 927	5 847	5 767	5 294	5 326	6 056
Liquid fuels	**586 070**	**611 190**	**612 766**	**621 422**	**617 625**	**617 308**	**650 047**
Vehicle fleet (petrol)	205 090	206 256	197 914	197 169	195 820	191 838	205 263
Vehicle fleet (diesel)	380 981	404 934	414 852	424 253	421 804	425 470	444 783
Total	**2 113 380**	**2 090 472**	**2 044 022**	**2 004 651**	**2 043 711**	**2 027 339**	**2 017 361**
Emissions (tCO_2e)	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Electricity	**409 900**	**405 809**	**377 343**	**359 795**	**364 907**	**346 522**	**364 009**
Wastewater	121 512	125 509	121 875	121 479	133 140	119 258	125 876
Buildings	130 544	118 980	100 452	85 398	83 595	85 152	92 385
Streetlights	94 912	97 016	93 238	91 989	88 354	73 216	77 932
Pump stations	42 923	43 875	42 166	41 601	40 924	49 858	51 807
Bulk water	18 396	18 803	18 071	17 829	17 539	17 729	14 396
Traffic lights	1 612	1 626	1 542	1 500	1 355	1 309	1 612
Liquid fuels	**42 701**	**44 567**	**44 725**	**45 374**	**45 097**	**45 093**	**47 469**
Vehicle fleet (petrol)	14 303	14 384	13 802	13 750	13 656	13 379	14 315
Vehicle fleet (diesel)	28 398	30 183	30 923	31 623	31 441	31 714	33 154
Total	**452 601**	**450 377**	**422 068**	**405 169**	**410 004**	**391 615**	**411 477**
Energy costs (real 2016 ZAR)	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Electricity	**520 104 281**	**520 882 082**	**511 436 749**	**502 397 733**	**505 567 585**	**482 188 708**	**466 401 840**
Wastewater	154 181 513	161 099 241	165 184 515	169 625 738	184 460 836	165 949 239	161 283 744
Buildings	165 641 556	152 718 223	136 148 820	119 244 979	115 818 952	118 490 078	118 372 712
Streetlights	120 430 255	124 526 134	126 370 860	128 447 572	122 412 130	101 880 528	99 854 100
Pump stations	54 463 605	56 315 933	57 150 195	58 089 371	56 699 116	69 377 595	66 380 333
Bulk water	23 341 545	24 135 400	24 492 941	24 895 445	24 299 621	24 669 812	18 445 152
Traffic lights	2 045 808	2 087 152	2 089 418	2 094 628	1 876 929	1 821 455	2 065 799
Liquid fuels	**216 570 807**	**237 884 340**	**238 234 639**	**198 982 224**	**184 167 073**	**193 901 248**	**226 007 871**
Vehicle fleet (petrol)	83 612 116	88 902 836	86 049 455	72 966 339	69 219 359	69 638 879	80 471 655
Vehicle fleet (diesel)	132 958 691	148 981 504	152 185 184	126 015 885	114 947 714	124 262 369	145 536 216
Total	**736 675 088**	**758 766 422**	**749 671 388**	**701 379 957**	**689 734 658**	**676 089 956**	**692 409 710**

10.6 FUEL PRICES AND TRANSPORT

TABLE A34: CAPE TOWN VEHICLE POPULATION, EXCLUDING TRAILERS

	2008	2009	2010	2011
Heavy-load vehicle (GVM >3 500 kg equip to draw)	11 590	11 764	11 916	12 713
Heavy-load vehicle (GVM >3 500 kg, not to draw)	8 620	8 107	7 721	7 314
Heavy passenger mv (12 or more persons)	3 377	3 267	3 240	3 433
Minibus	11 711	11 564	11 785	11 738
Light-load vehicle (GVM 3 500 kg or less)	158 457	158 767	159 725	162 728
Light passenger mv (fewer than 12 persons)	712 276	719 441	737 133	761 049
Motorcycle/motortricycle/quadrucycle	46 724	49 070	48 662	51 066
Special vehicle	14 105	13 758	13 789	13 917
Unknown	1 817	1 821	1 799	1 759
Total	**968 677**	**977 559**	**995 770**	**1 025 717**

Source: eNatis.

TABLE A35: RETAIL PRICES OF PETROL AND DIESEL, 2001–2018, IN REAL TERMS, AND YEAR-ON-YEAR GROWTH RELATIVE TO GROWTH IN THE CONSUMER PRICE INDEX (CPI)

Data	Petrol[1]	Diesel[1]	CPI	Petrol[2]	Diesel[2]	Petrol	Diesel
Year	Average of 93 and 95 price (nominal)	Average of 0,05% and 0,005% price (nominal)	Stats SA	Average of 93 and 95 price (constant 2016)	Average of 0,05% and 0,005% price (constant 2016)	Year-on-year growth (constant 2016)	Year-on-year growth price (constant 2016)
2001	3,62	3,02	42,00	8,43	7,19	-	-
2002	3,92	3,57	45,90	8,35	7,60	-0,91%	5,76%
2003	3,82	3,38	48,50	7,70	6,81	-7,82%	-10,45%
2004	4,31	3,84	49,20	8,58	7,62	11,38%	11,96%
2005	5,10	4,84	50,90	9,80	9,29	14,22%	21,91%
2006	6,00	5,72	53,20	11,03	10,52	12,63%	13,21%
2007	6,58	6,20	57,00	11,29	10,63	2,37%	1,05%
2008	8,81	9,29	63,60	13,55	14,29	20,01%	34,38%
2009	7,18	6,60	67,80	10,36	9,52	-23,56%	-33,37%
2010	7,99	7,35	70,70	11,05	10,17	6,69%	6,79%
2011	9,66	9,19	74,20	12,73	12,12	15,20%	19,15%
2012	11,18	10,66	78,40	13,94	13,30	9,50%	9,74%
2013	12,50	11,88	82,90	14,74	14,02	5,73%	5,42%
2014	13,38	12,58	88,00	14,87	13,98	0,87%	-0,29%
2015	11,91	10,65	92,00	12,66	11,32	-14,88%	-19,03%
2016	12,09	10,38	97,80	12,09	10,38	-4,48%	-8,25%
2017	13,08	11,72	103,00	12,41	11,13	2,69%	7,17%
2018	14,78	13,74	107,80	13,41	12,47	8,00%	12,03%
CAGR (2001–2018)	-	-	-	2,77%	3,29%	-	-
CAGR (2008–2018)	-	-	-	-0,11%	-1,36%	-	-

[1]All values are for prices at the coast, aside from diesel (0,005%), which does not have a differentiated price.
Link: http://www.energy.gov.za/files/energyStats_frame.html
[2]Strips out effect of inflation.
Source: http://www.statssa.gov.za/publications/P0141/CPIHistory.pdf. Table B1– CPI headline index numbers (Dec 2016 = 100).

2012	2013	2014	2015	2016	2017	2018[1]	CAGR (2008-2017)
14 064	14 615	15 838	17 065	17 460	18 763	19 058	5,50%
7 201	6 926	6 719	6 564	6 411	6 389	6 040	-3,27%
3 668	3 908	4 040	4 135	4 147	4 398	18 505	2,98%
11 877	11 880	12 263	12 899	13 545	15 240		2,97%
166 760	170 597	174 957	182 487	184 718	190 607	183 928	2.07%
792 341	821 208	849 441	879 864	891 305	921 307	916 307	2,90%
53 911	56 954	56 911	58 773	58 948	56 606	44 950	2,15%
14 203	14 364	14 593	14 880	14 825	15 151	13 601	0,80%
1 711	1 699	1 663	1 652	1 641	1 600	1 534	-1,41%
1 065 736	**1 102 151**	**1 136 426**	**1 178 317**	**1 193 001**	**1 230 061**	**1 203 922**	**2.69%**

[1]Light vehicles show an offset in 2018. This occurs over one month in the data and is a statistical adjustment, not a change in actual population. Clarification had not been obtained at the time of publication.

TABLE A36: DIESEL AND PETROL SALES OVER TIME

	2012	2013	2014	2015	2016	2017	2018
Petrol (lit)	1 405 921 718	1 236 399 635	1 260 383 393	1 300 642 350	1 381 291 254	1 343 450 864	1 304 704 292
Diesel (lit)	1 104 352 854	1 160 861 950	1 330 662 072	1 376 081 759	1 327 867 798	1 305 415 491	1 238 725 151
Petrol and diesel (lit)	2 510 274 572	2 397 261 585	2 591 045 465	2 676 724 109	2 709 159 052	2 648 866 355	2 543 429 443
Petrol (GJ)	48 082 523	42 284 868	43 105 112	44 481 968	47 240 161	45 946 020	44 620 887
Diesel (GJ)	42 075 844	44 228 840	50 698 225	52 428 715	50 591 763	49 736 330	47 195 428
Petrol and diesel (GJ)	90 158 367	86 513 708	93 803 337	96 910 683	97 831 924	95 682 350	91 816 315

Source: DMRE.
Diesel excludes use in Ankerlig.

TABLE A37: DIESEL AND PETROL SALES GROWTH OVER TIME

	Petrol	Diesel
Total growth in sales between 2012 and 2018	5,52%	12,17%
Average annual growth in sales between 2012 and 2018	1,08%	1,93%

Petrol sales growth values calculated using base year of 2013, since 2011 and 2012 are outlier sales years (much higher than other years on time series).

TABLE A38: BUS, MINIBUS AND RAIL OPERATIONS IN CAPE TOWN

City buses	MyCiTi operations	Golden Arrow bus operations	Sibanye operations	Minibus	Metrorail
Fleet size	82	1 010	50	7 258	72
Passengers/day	10 754	220 028	19 972	323 000	202 228
No. routes operated	40	2 000 (commuter routes)	2 269	3 500	11
Avg trip length (km) – main routes only	9	19	19	19	23

Source: City of Cape Town, 2013–2018 CITP (2012, 2013), Public Transport Operations – 2020, CITP 2017–2022 (2013, 2015).

TABLE A39: ESTIMATED DAILY RAIL COMMUTERS

Year	Estimated daily rail commuters
2000	675 607
2004	621 285
2007	635 046
2012	621 833
2013	635 832
2014	608 533
2015	575 845
2016	454 000
2017	360 000
2018	202 228
2019	189 607
Avg trip length (km) – main routes only	23

Extrapolated from CITP data using trend for Western Cape in PRASA Annual Report 2018/19.

TABLE A40: AVERAGE TOTAL TRAVEL TIME (MINUTES)

	Low income	Middle income	High income
To work	53	57	52
To education	31	31	33

Source: Cape Town Household Travel Survey, 2013.

TABLE A41: TRAVEL TIMES TO WORK BY DIFFERENT TRANSPORT MODES

To work	Average	Minimum	Maximum
Minibus taxi	39	20	72
Bus	79	26	124
Car	21	7	53
Bus rapid transit	38	24	64

Source: Development of an Urban Development Index (UDI) Cape Town, 2019.

TABLE A42: CITYWIDE MODAL SPLIT TO WORK BY MAIN MODE IN MORNING PEAK PERIOD (2018)

Modal share	Private transport	Rail	Minibus taxi	Bus	Bus rapid transit	Non-motorised transport
All modes	51%	13%	21%	11%	2%	2%
Aggregated public	51%	47%				2%
Public and private only	52%	48%				-
Public only	-	28%	46%	23%	4%	-

Source: Development of an Urban Development Index (UDI) Cape Town, 2019.

TABLE A43: DIRECT TRANSPORT EXPENDITURE PER INCOME GROUP (2018)

Income group	Income stratification	Employed population	Average monthly income	Average direct cost expenditure vs monthly income (%)		
				Public transport	Private	Mix public and private
Low income	<R 4 640	47%	R2 400	17%	35%	26%
Medium income	R4 641–R37 100	45%	R14 100	3%	23%	14%
High income	>R37 101	8%	R70 800	1%	9%	7%

Source: Development of an Urban Development Index (UDI) Cape Town, 2019.

TABLE A44: ESTIMATED TRANSPORT MODE SHARE OF GREENHOUSE GAS EMISSIONS, PASSENGER-KM AND TONNE-KM IN CAPE TOWN (2017)

Mode	2017 GHG emissions (tCO_2e)[3]	2017 GHG emissions (% share of road transport)[3]	Estimated billion passenger-km (bpkm) and tonne-km (btkm)[1,2]	Estimated share billion passenger km and tonne km[1,2]
Heavy commercial vehicle	1 516 329	25%	18,6 btkm	90,4%
Medium commercial vehicle	132 966	2%	0,48 btkm	2,3%
Light commercial vehicle	1 320 639	22%	1,5 btkm	7,3%
Total - Freight	**2 969 934**	**49%**	**20,6 btkm**	**100%**
Passenger car	2 546 982	42%	18,1 bpkm	50,0%
Motorcycle	53 838	1%	0,5 bpkm	1,4%
Minibus	280 030	5%	10,1 bpkm	27,9%
Bus	176 356	3%	3,1 bpkm	8,6%
Subtotal - Passenger Road	**3 057 206**	**98%**	**31,8 bpkm**	**87,9%**
Metrorail	132 413	2%	3,05 bpkm	8,4%
Bicycle	0	-	0,02 bpkm	0,06%
Walk	0	-	1,3 bpkm	3,6%
Total - Passenger	**3 189 619**	**100%**	**36,2 bpkm**	**100%**

Source:[1]Econ 399-17 LNG Project –Techno-Economic Analysis of Energy in the Western Cape Transport Sector.

[2]In order to balance fuel sales this analysis should be considered to include long-distance transport and a significant amount of activity outside of commuting corridors that is not accounted for in the City's published trip estimate figures. The high activity levels arising for the fuel balance for all registered buses relative to the better known figures for the large operators such as MyCiTi and Golden Arrow, suggest some of this diesel may rather be used by commercial vehicles at a higher energy intensity than that assumed. The detailed investigation required to resolve this was however beyond the scope of this project.

[3]The data is derived from the activity levels assumed for registered vehicles to balance fuel sales after accounting for estimated regional imports and exports, and non-transport fuel use. Not based on local activity surveys or transport flow modelling.

10.7 GREENHOUSE GASES AND LOCAL AIR POLLUTANTS

TABLE A45: GLOBAL PROTOCOL FOR COMMUNITY-SCALE GREENHOUSE GASES (tCO_2e)

Ref no.	Greenhouse gas emissions by sector/subsector (tCO_2e)	2018	
		Scope 1	Scope 2
I	STATIONARY ENERGY		
I.1	Residential buildings	103 707	3 640 463
I.2	Commercial and institutional buildings and facilities	26 724	5 169 131
I.3	Manufacturing industries and construction	383 328	1 582 765
I.4.1/2/3	Energy industries	NO	IE
I.4.4	Energy generation supplied to the grid	305 634	
I.5	Agriculture, forestry and fishing activities	211 760	51 732
I.6	Non-specified sources	0	964 458
I.7	Fugitive emissions from mining, processing, storage and transportation of coal	NO	
I.8	Fugitive emissions from oil and natural gas systems	NE	
SUBTOTAL	City-induced framework only	725 519	11 408 549
II	TRANSPORTATION		
II.1	On-road transportation	6 256 872	NO
II.2	Railways	0	119 074
II.3	Waterborne navigation	IE	NO
II.4	Aviation	IE	NO
II.5	Off-road transportation	IE	NO
SUBTOTAL	City-induced framework only	6 256 872	119 074
III	WASTE		
III.1.1/2	Solid waste generated in the city	1 721 214	
III.1.3	Solid waste generated outside the city	NO	
III.2.1/2	Biological waste generated in the city	987	
III.2.3	Biological waste generated outside the city	NO	
III.3.1/2	Incinerated and burned waste generated in the city	NE	
III.3.3	Incinerated and burned waste generated outside the city	NO	
III.4.1/2	Wastewater generated in the city	119 109	
III.4.3	Wastewater generated outside the city	NO	
SUBTOTAL	City-induced framework only	1 841 310	
IV	INDUSTRIAL PROCESSES AND PRODUCT USES	NE	NE
V	AGRICULTURE, FORESTRY AND OTHER LAND USES	NE	NE
VI	OTHER SCOPE 3	NE	NE
TOTAL	**City-induced framework only**	**8 823 700**	**11 527 623**

General note: NO = Not occurring IE = Included elsewhere NE = Not estimated

Scope 1: Emissions within city boundaries. Scope 2: Emissions from cross-boundary sources (electricity).
Scope 3: Emissions from outside the city boundaries, directly or indirectly caused by the city.

2018		Notes	
Scope 3	Total		
407 992	4 152 163	Emissions from electricity use (auxiliary consumption) by energy industries are included in I.2 or I.3.	*Sources: IPCC; Eskom; DMRE; City of Cape Town*
579 306	5 775 161		
177 395	2 143 488		
IE	0		
	304 331		
5 796	269 288		
108 136	1 072 594		
	0		
	0		
1 278 625	13 412 693		
NO	6 256 872	Negligible emissions from electricity in on-road use; off-road emissions (from vehicles at airports) incl. in on-road; scope 1 aviation and waterborne navigation emissions (in-boundary travel) incl. in scope 3 (outside-boundary travel).	*Sources: IPCC; Eskom; DMRE; City of Cape Town*
13 340	132 413		
69 398	69 398		
1 353 572	1 353 572		
NO	0		
1 436 310	7 812 255		
NO	1 721 214	All waste generated inside city boundaries is treated as inside boundaries. No waste is received from outside city boundaries. Emissions from composting and incineration not estimated (no data); will be negligible in comparison to emissions from solid waste treatment (landfill) and wastewater treatment.	*Sources: City of Cape Town and Enviroserve (waste data); Stats SA (population); JG Afrika, 2018 (waste characterisation); IPCC (calculation methodology and defaults)*
	0		
NO	987		
	0		
NO	0		
	0		
NO	119 109		
	0		
0	1 841 310		
NE	NE		
NE	NE		
NE	NE		
2 714 935	**23 066 258**		

Key emissions sources directly caused by city activities.

Other emissions indirectly caused by city activities.

Emissions not related to city activities, but occurring within city boundaries.

TABLE A46: POLLUTANTS BY SECTOR AND FUEL (2018)

Tonnes	SO_2	NOx	VOCs	PM_{10}	$PM_{2,5}$
Sector					
Residential	**158**	**60**	**44**	**31**	**23**
Coal	-	-	-	-	-
LPG	0,2	24	9	1	1
Paraffin	156	28	2	4	4
Wood	1	8	34	27	19
Commercial, industrial and agricultural	**2 934**	**1 141**	**1 186**	**1 289**	**1 025**
Coal	1 181	93	311	255	102
Diesel	1 221	801	656	866	801
Fuel oil	311	158	30	18	16
LPG	0,1	9	3	0,5	0,5
Paraffin	215	38	2	5	5
Wood	6	42	183	144	101
Transport (road)	**12 517**	**30 240**	**52 507**	**8 092**	**7 408**
Petrol	2 218	23 485	46 969	783	652
Diesel	10 299	6 755	5 537	7 309	6 755
Power plants	**1 002**	**655**	**536**	**707**	**654**
Diesel (Ankerlig)	997	654	536	707	654
Jet fuel (Acacia, Roggebaai, Athlone)	6	1	0,1	0,1	0,1

Source: City of Cape Town, (Air Quality) and Department of Mineral Resources and Energy.
Excludes pollutants from aviation and maritime transport.

TABLE A47: PER-CAPITA GREENHOUSE GAS EMISSIONS BY CITY AND COUNTRY (tCO_2e PER CAPITA)

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Argentina	11,05	10,48	10,54	9,95	9,94	10,06	9,88	9,93	9,09	9,03	8,89
Australia	29,04	29,22	27,29	28,86	28,29	24,01	24,12	23,79	23,87	25,33	24,79
Belgium	11,32	10,57	11,15	9,95	9,83	9,90	9,29	9,68	9,75	9,53	9,53
Brazil	10,58	10,36	10,75	6,43	6,58	6,64	6,77	6,62	7,00	7,03	6,78
China	6,38	6,80	7,38	7,71	7,91	8,21	8,18	8,13	8,13	8,23	8,40
Germany	10,83	10,16	10,55	10,26	10,41	10,60	10,06	10,02	9,97	9,72	9,37
Ghana	3,03	3,02	3,02	2,44	2,49	2,54	2,51	2,54	0,58	0,62	0,66
Nigeria	1,84	1,68	1,77	1,84	1,82	1,85	1,86	1,78	1,78	1,77	1,83
Norway	5,30	5,12	5,94	6,29	5,98	5,73	5,72	5,71	5,54	5,30	5,35
South Africa	10,13	9,58	9,88	9,43	9,64	9,67	9,74	9,16	9,04	9,15	9,01
Sweden	5,14	4,68	5,23	3,58	3,25	3,05	2,88	2,84	3,31	3,23	2,95
Cape Town[1]	-	-	-	-	5,63	5,40	5,24	5,12	4,93	4,58	4,54

Source: CAIT Climate Data Explorer.
[1]Cape Town emissions from energy and waste only.

10.8 WASTE DATA

TABLE A48: WASTE COMPOSITION AND QUANTITIES DISPOSED IN CAPE TOWN, 2011–2019

Waste type (tonnes)	2011	2012	2013	2014	2015	2016	2017	2018	2019
Waste by city-owned landfill sites									
General waste	1 273 765	1 250 841	1 640 392	1 614 315	1 190 483	1 136 485	1 183 652	1 089 232	1 221 161
Hazardous waste	41 397	43 000	23 909	21 003	19 773	26 754	18 396	9 347	5 976
Builders' rubble	322 576	310 329	382 271	602 690	942 232	1 385 188	1 228 449	887 574	334 243
Garden greens	65 312	90 576	96 353	41 374	10 450	11 401	8 971	5 619	13 146
Waste diverted	387 888	400 905	478 624	644 064	952 682	1 396 588	1 237 421	893 193	347 389
Waste collected	1 703 050	1 694 746	2 142 925	2 279 382	2 162 938	2 559 828	2 439 469	1 991 772	1 574 526
Waste disposed	1 315 162	1 293 841	1 664 301	1 635 318	1 210 256	1 163 240	1 202 048	1 098 579	1 227 137
Waste diverted as share of total waste (%)	23%	24%	22%	28%	44%	55%	51%	45%	22%
Private waste landfill sites									
Dry hazardous	85 282	86 948	83 616	116 722	162 024	155 761	132 065	100 884	108 897
General	193 326	160 285	226 367	238 290	212 550	245 254	320 522	373 729	455 783
Rubble	80 293	95 241	65 344	51 451	168 845	131 562	59 616	91 767	84 685
Sludge	41 258	42 072	40 443	79 777	44 713	13 942	21 661	25 062	19 755
Liquids	34 922	39 236	30 608	34 949	67 734	42 855	72 365	76 935	73 831
Waste collected	435 080	423 782	446 378	521 189	655 866	589 374	606 229	668 377	742 951
Waste diverted	80 293	176 549	136 395	166 177	281 292	188 359	153 642	193 764	178 271
Waste disposed	354 788	328 541	381 034	469 738	487 021	457 812	546 613	576 610	658 266
Total waste collected	**2 138 130**	**2 118 528**	**2 589 303**	**2 800 571**	**2 818 804**	**3 149 202**	**3 045 698**	**2 660 149**	**2 317 477**
Total waste diverted	**468 181**	**577 454**	**615 019**	**810 241**	**1 233 974**	**1 584 947**	**1 391 063**	**1 086 957**	**525 660**
Total waste dosposed	**1 669 949**	**1 622 382**	**2 045 335**	**2 105 056**	**1 697 277**	**1 621 052**	**1 748 661**	**1 675 189**	**1 885 403**

Source: City of Cape Town, Solid Waste Management Department and Vissershok waste management facility.

TABLE A49: WASTE QUANTITIES BY LANDFILL SITE (TONNES)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Vissershok (City-owned)	610 851	633 755	706 306	664 106	585 612	586 200	577 684	543 575	741 496
Coastal Park (City-owned)	324 377	338 386	597 756	713 850	340 918	307 631	355 887	373 361	485 595
Bellville (City-owned)	379 934	321 701	360 239	257 362	283 727	269 408	268 477	181 644	46
Vissershok (private)	354 788	328 541	381 034	469 738	487 021	457 812	546 613	576 610	658 266
Total waste disposed	**1 669 949**	**1 622 382**	**2 045 335**	**2 105 056**	**1 697 277**	**1 621 052**	**1 748 661**	**1 675 189**	**1 885 403**

TABLE A50: TOTAL METHANE EMISSIONS EMITTED PER SITE (tCO_2e)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Vissershok (City-owned)	666 485	691 474	770 633	724 590	638 947	639 589	630 297	540 363	737 115
Coastal Park (City-owned)	353 920	369 204	652 197	778 865	371 967	335 649	388 300	371 155	482 726
Bellville (City-owned)	414 536	351 000	393 048	280 801	309 567	293 945	292 929	180 570	46
Vissershok (private)	387 100	358 463	415 737	512 520	531 377	499 508	596 396	629 125	718 218
Biological waste (compost) generated in the city								987	
Total waste emissions	**1 822 041**	**1 770 142**	**2 231 615**	**2 296 776**	**1 851 858**	**1 768 690**	**1 907 922**	**1 722 201**	**1 938 105**

*Methane emissions * Global warming potential*
Methane emissions calculated according to methane commitment method.

TABLE A51: WASTEWATER TREATMENT BY PLANT (ML)

Plant name	Plant treatment	2012	2013	2014	2015	2016	2017	2018	2019	2020
Athlone	Aerobic treatment plant (well managed)	52 435	52 429	47 337	41 491	39 039	33 832	32 424	31 257	26 645
Bellville	Aerobic treatment plant (well managed)	21 592	21 590	19 519	17 300	16 452	11 309	9 999	11 493	12 631
Borcherds Quarry	Aerobic treatment plant (well managed)	14 276	14 274	13 844	14 047	13 678	11 163	10 447	11 338	11 158
Camps Bay outfall	Untreated, discharge to ocean	887	887	932	830	821	592	497	609	571
Cape Flats	Aerobic treatment plant (well managed)	43 216	43 210	46 129	43 476	42 547	36 142	30 556	33 333	39 275
Fisantekraal	Aerobic treatment plant (well managed)	4 434	4 434	4 575	3 875	3 974	3 472	3 326	4 053	4 155
Gordon's Bay	Aerobic treatment plant (well managed)	1 612	1 612	1 537	1 296	1 190	938	891	921	1 043
Green Point outfall	Untreated, discharge to ocean	10 558	10 557	10 864	10 225	9 997	8 414	6 696	7 744	6 444
Hout Bay outfall	Untreated, discharge to ocean	1 741	1 740	2 191	2 037	1 953	1 642	1 637	1 905	1 771
Klipheuwel	Aerobic treatment plant (overloaded)	43	43	49	49	86	69	76	71	72
Kraaifontein	Aerobic treatment plant (well managed)	5 546	5 546	5 133	4 561	2 399	1 679	1 365	1 440	1 713
Llandudno	Aerobic treatment plant (well managed)	77	77	73	68	60	44	32	44	53
Macassar	Aerobic treatment plant (well managed)	13 919	13 917	14 040	12 028	11 391	8 391	8 811	9 216	9 709
Melkbosstrand	Aerobic treatment plant (well managed)	1 504	1 504	1 503	1 291	1 317	889	711	778	778
Miller's Point	Aerobic treatment plant (well managed)	10	10	17	10	31	3	2	4	3
Mitchells Plain	Aerobic treatment plant (well managed)	13 102	13 101	12 634	12 159	11 685	9 719	7 562	8 507	8 390
Oudekraal	Aerobic treatment plant (well managed)	4	4	3	2	3	1	1	3	5
Philadelphia	Pond system (untreated)	-	-	-	20	23	20	17	14	18
Potsdam	Aerobic treatment plant (well managed)	19 287	19 284	19 970	19 735	18 011	16 367	13 405	14 146	14 495
Scottsdene	Aerobic treatment plant (well managed)	3 913	3 913	4 353	4 146	4 063	3 542	2 785	2 821	2 616
Simon's Town	Aerobic treatment plant (well managed)	798	798	776	622	584	444	353	466	545
Wesfleur – domestic	Aerobic treatment plant (well managed)	3 672	3 671	4 238	3 484	3 833	3 073	2 379	2 520	2 629
Wesfleur – industrial	Aerobic treatment plant (well managed)	215	215	-	-	-	542	1 116	1 321	1 347
Wildevoëlvlei	Aerobic treatment plant (well managed)	4 134	4 134	4 224	3 403	3 365	2 495	2 158	2 452	2 533
Zandvliet	Aerobic treatment plant (overloaded)	31 829	31 825	34 893	36 140	32 098	26 558	21 655	25 191	26 745
Total	**2012 value taken as average of 2013 and 2014**	**248 804**	**248 773**	**248 836**	**232 296**	**218 598**	**181 340**	**158 900**	**171 645**	**175 339**

Source: City of Cape Town, Water and Sanitation.

TABLE A52: WASTEWATER GREENHOUSE GAS EMISSIONS (tCO_2e)

	2012	2013	2014	2015	2016	2017	2018	2019
Methane emissions	48 250	49 361	55 109	61 771	60 244	61 373	58 458	64 197
Nitrous oxide emissions	53 339	54 568	55 795	57 009	58 222	59 418	60 651	61 900
Total	**101 589**	**103 929**	**110 903**	**118 780**	**118 467**	**120 791**	**119 109**	**126 097**

TABLE A53: WASTE SECTOR EMISSIONS (tCO_2e)

	2012	2013	2014	2015	2016	2017	2018	2019
Solid waste only	1 770 142	2 231 615	2 296 776	1 851 858	1 768 690	1 907 922	1 722 201	1 938 105
Wastewater only	101 589	103 929	110 903	118 780	118 467	120 791	119 109	126 097
All waste	**1 871 730**	**2 335 544**	**2 407 679**	**1 970 638**	**1 887 157**	**2 028 714**	**1 841 310**	**2 064 202**

10.9 CONVERSION FACTORS

TABLE 54: IPCC EMISSIONS FACTORS

	Amount of greenhouse gas	Amount of fuel	CO_2	CH_4	N_2O	CO_2 (b)	Source	tCO_2e
Aviation gasoline (stationary combustion)	kg	TJ	70 000	10	0,6		IPCC, 2006	70,439
Other bituminous coal*	kg	TJ	94 600	10	1,5		IPCC, 2006	95,278
Coke, oven coke and lignite coke, stationary combustion (commercial/institutional sector)	kg	TJ	107 000	10	1,5		IPCC, 2006	107,678
Diesel	kg	TJ	74 100	10	0,6		IPCC, 2006	74,539
Jet kerosene	kg	TJ	71 500	10	0,6		IPCC, 2006	71,939
LPG	kg	TJ	63 100	5	0,1		IPCC, 2006	63,267
Paraffin	kg	TJ	71 900	10	0,6		IPCC, 2006	72,339
Petrol	kg	TJ	69 300	10	0,6		IPCC, 2006	69,739
Residual fuel oil	kg	TJ	77 400	10	0,6		IPCC, 2006	77,839
Other primary solid biomass, stationary combustion (commercial/institutional sector)**	kg	TJ	N/A	30	4,0	100 000	IPCC, 2006	1,900
Natural gas	kg	TJ	56 100	5	0,1		IPCC, 2006	56,267

Source: https://emissionfactors.com/. Original source: IPCC, 2006.
* *Other coal categories are: (i) anthracite, (ii) coking coal, (iii) lignite/brown coal, and (iv) subbituminous coal.*
** *Other bioenergy categories are: (i) biogasoline; (ii) municipal waste, biomass fraction, stationary combustion; (iii) other biogas, stationary combustion; and (iv) other liquid biofuels.*
tCO_2e converts non-biogenic gases (all except CO_2 (b)) into CO_2-equivalent, using global warming potentials.
Blue values are calculations.

TABLE A55: GLOBAL WARMING POTENTIAL

Global warming potential (GWP)	2AR	3AR	4AR	5AR
CO_2	1	1	1	1
CH_4	21	23	25	28
N_2O	310	296	298	265

Source: IPCC Assessment Report (AR).
GWPs are updated by IPCC as new data become available. Interpretation: According to 5AR, methane has 28 times the warming potential of carbon dioxide. Previous City inventories used GWP from earlier ARs, one of the reasons for discrepancies in total emissions when comparing new-method outputs with inventories produced in previous years.

TABLE A56: SOUTH AFRICAN ENERGY CONVERSION FACTORS

Energy carrier	Energy content	Unit	Density (kg/ℓ)	MJ/kg
LPG	26,7	MJ/ℓ	0,54	49,4
Power paraffin	37,5	MJ/ℓ	0,81	46,1
Gas SASOL	18	MJ/m³		
Diesel	38,1	MJ/ℓ	0,84	45,4
Electricity	3,6	MJ/kWh		
Natural gas	41	MJ/m³		
Heavy fuel oil	41,6	MJ/ℓ	0,98	42,3
Petrol	34,2	MJ/ℓ	0,72	47,3
Paraffin illuminating CSS (Stats SA) data	37	MJ/ℓ	0,79	47
Aviation gas	33,9	MJ/ℓ	0,73	46,4
Jet fuel	34,3	MJ/ℓ	0,79	43,3
Coal Eskom average	20,1	MJ/kg		
Coal (general purpose)	24,3	MJ/kg		
Coal (coking)	30,1	MJ/kg		
Coke	27,9	MJ/kg		
Coke oven gas	17,3	MJ/m³		
Blast furnace gas	3,1	MJ/m³		
Bagasse (wet)	7	MJ/kg		
Bagasse fibre (dry)	14	MJ/kg		
Biomass (wood dry typical)	17	MJ/kg		
Gas SASOL – methane-rich	35	MJ/m³		

Source: DoE (2016), Integrated Energy Plan, Annexure A: Technology Assumptions (Technology Costs and Technical Parameters), Appendix A: Technology Data Input Tables, Table1: Energy carrier properties.
http://www.energy.gov.za/files/IEP/2016/IEP-AnnexureA-Technology-Assumptions-Technology-Costs-And-Technical-Parameters.pdf

TABLE A57: EMISSION FACTORS USING SOUTH AFRICA ENERGY CONVERSION FACTORS

	Emissions (kg/TJ) [IPCC]				Energy conversion [DoE/DMRE]			
Fuel	CO_2	CH_4	N_2O	CO_2 (b)	Value	Unit	Value	Unit
Aviation gasoline	70 000	10	0,6	0	33,9	MJ/lit	0,000034	TJ/lit
Coal (Eskom average)	94 600	10	1,5	0	20,1	MJ/kg	0,000020	TJ/kg
Coal (general purpose)	94 600	10	1,5	0	24,3	MJ/kg	0,000024	TJ/kg
Coke	107 000	10	1,5	0	27,9	MJ/kg	0,000028	TJ/kg
Diesel oil	74 100	10	0,6	0	38,1	MJ/lit	0,000038	TJ/lit
Jet kerosene	71 500	10	0,6	0	34,3	MJ/lit	0,000034	TJ/lit
LPG	63 100	5	0,1	0	26,7	MJ/lit	0,000027	TJ/lit
Paraffin	71 900	10	0,6	0	37,0	MJ/lit	0,000037	TJ/lit
Petrol	69 300	10	0,6	0	34,2	MJ/lit	0,000034	TJ/lit
Residual fuel oil	77 400	10	0,6	0	41,6	MJ/lit	0,000042	TJ/lit
Wood (dry, typical)	N/A	30	4,0	100 000	17,0	MJ/kg	0,000017	TJ/kg
Natural gas	56 100	5	0,1	0	41,0	MJ/m³	0,000041	TJ/m³

Note: Emissions reported as grams of the relevant gas (not CO_2e).
Coal (Eskom average) factor can be used for coal burned in power plant; coal (general purpose) can be used for coal burned by industrial/commercial/residential sector. Residual fuel oil is also known as heavy fuel oil, furnace oil, etc. 'Wood (dry, typical)' uses IPCC emissions factors for category "other primary solid biomass, stationary combustion (commercial/institutional sector)". Coal uses IPCC emissions factors for category "other bituminous coal". Aviation gasoline uses IPCC emissions factors for category "aviation gasoline (stationary combustion)". Non-stationary combustion does not appear as an option.
Values in red reference previous tables. Blue values are calculations.

TABLE A58: AIR POLLUTANT FACTORS

Source	Uncertainty	Units	SO_2	NOx	VOCs	PM10	PM2,5
Residential							
Coal	Medium	g/kg	19	1,5	5	4,1	1,64
Paraffin	Low	g/ℓ	8,5	1,5	0,09	0,2	0,2
LPG	Low	g/kg	0,01	1,4	0,5	0,07	0,07
Wood	Medium	g/kg	0,75	5	22	17,3	12,1
Transport							
Petrol vehicles	Medium	g/ℓ	1,7	18	36	0,6	0,5
Diesel vehicles	Medium	g/ℓ	9,3	6,1	5	6,6	6,1
Brake and tyre wear	Medium	g/km	0	0	0	0,0021	
Paved roads	High	g/km	0	0	0	0,23	
Unpaved roads	High	g/km	0	0	0	75	
Ship diesel	Medium	g/ℓ	9,3	100	4,2	7,1	6,4
Ship bunker oil	Medium	g/ℓ	63	32	6	3,7	3,3

Source: City of Cape Town, Air Quality Department (2014).

TABLE A59: WASTE FACTORS

Methane correction factors	
Managed landfills (have vent pipes)	1
Unmanaged landfills (≥5 m deep)	0,8
Unmanaged landfills (<5 m deep)	0,4
Uncategorised landfill	0,6
Other factors	
Fraction of degradable organic carbon that is ultimately degraded (DOCF)	0,5
Fraction of methane in landfill gas (F)	0,5
Ratio between methane and carbon	1,3
Methane destruction efficiency	90%
Global warming potential (GWP) for methane (AR5)	28
Oxidation factors	
Well-managed landfills	0,1
Unmanaged landfills	0

TABLE A60: WASTEWATER FACTORS

Methane correction factors	
Untreated	
Sea, river or lake discharge	0,1
Stagnant sewer	0,5
Flowing sewer	0
Treated	
Aerobic treatment plant (well managed)	0
Aerobic treatment plant (overloaded)	0,3
Anaerobic digester for sludge	0,8
Anaerobic reactor	0,8
Anaerobic shallow lagoon (<2 m)	0,2
Anaerobic deep lagoon (>=2 m)	0,8
Septic system	0,5
Latrine (dry climate, small family)	0,1
Latrine (dry climate, many users)	0,5
Latrine (wet climate)	0,7
Latrine (regular sediment removal for fertiliser)	0,1
General factors	
Biochemical oxygen demand, default value for Africa	37 g/person/day
Correction factor for industrial BOD for collected wastewater	1,25
Maximum methane-producing capacity	0,6 kg CH4/kg BOD
Global warming potential (GWP) for methane (AR5)	28

TABLE A61: WASTEWATER

General factors	
Global warming potential (GWP) for nitrous oxide (AR5)	265
Protein consumption, average for South Africa	29,93 kg/person/year
Factor to adjust for non-consumed protein, in countries with no organic garbage disposal via sinks	1,1
Fraction of nitrogen in protein (kg N/kg protein)	0,16
Factor for industrial/commercial co-discharged protein into sewer system	1,25

10.10 METHODOLOGY NOTES

The 2015 State of Energy report already reflected an increase in the quality and availability of data compared to previous versions. This edition of the report has benefited from even greater availability of higher-quality data. This has allowed for different methodologies and analyses to be applied. As such, many of the statistics in this version of the report are not comparable to those in previous versions. These include electricity, transport, waste and, more importantly, a change in the financial base year from 2010 to 2016.

Methodologies by source:

State of Energy in South African Cities 2020

Energy intensity (GJ/person or GJ/GVA) for other metros

- Emissions intensity (tCO_2e/person or tCO_2e/GVA) for other metros

Department of Mineral Resources and Energy

- Fuel sales volumes: Fuel demand nationally and in the Western Cape (note that use in power plants was stripped out – power plant use calculated using NERSA data on power plant electricity generation, assumed plant efficiency of 30% and DMRE energy conversion factors).
- Energy balances: Coal, natural gas and biomass demand at national level. Excludes fuel use in power plants. No data for 2018. Coal demand for 2018 calculated as average of 2012 to 2017 values (since no trend in data over that time). Biomass and natural gas demand in 2018 obtained by extrapolation using growth between 2016 and 2017.

Stats SA

- Electricity generated and available for distribution (nationally and for Western Cape)

Western Cape Department of Environmental Affairs and Development Planning (2018) energy consumption and CO_2e emissions database for the Western Cape

- No reported use of natural gas in Western Cape. Assumed no use.
- Coal demand in Western Cape only available for 2012/13 and 2015/16 financial years, assumed representative of 2012 and 2015 calendar years respectively. Interpolated/extrapolated other years based on these two values.

Full methodology notes on State of Energy and Carbon 2021 report results can be accessed on the City of Cape Town's Open Data Portal: https://odp-cctegis.opendata.arcgis.com/

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